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NIIGATA

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of ISO 9001 and ISO 14001

INSTRUCTION MANUAL

FOR

NIIGATA DIESEL

MODEL

MG(L)28AHX

IHI Power Systems Co., Ltd.

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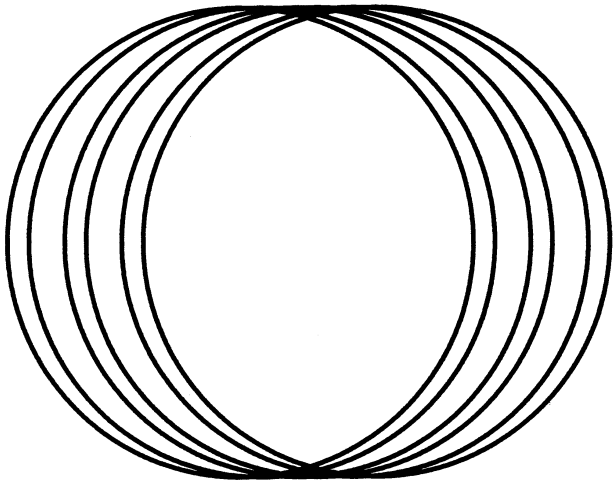

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1. FOREWORD AND SAFETY PRECAUTION

1.1 Foreword

This manual describes the engine construction, and its operating and maintenance procedures for the engine operator.

The manual does not necessarily cover all the details of the problems which might occur during engine operation. It is suggested that, after carefully reading the manual, you pay attention to the condition of the engine at all times and study the engine yourself so that appropriate steps can be taken quickly against whatever trouble the engine has developed.

It is important to perform routine inspection and maintenance to detect trouble symptoms and thus prevent trouble.

NOTES

(1) This manual gives general instruction for the engine, but no warranty provisions whatever.

(2) Any question about the contents of the manual should be addressed to the engine manufacturing plant via the Head Office, branch, or local office of Niigata Engineering.

(3) When exchanging a part, always use the part, which our company supplies.

(4) Include the following information in your order for parts.

(a) Customer's name（name of plant or ship)

(b) Engine model, Engine number

(c) Names of parts, parts catalog numbers

(Fig. No. , Item No. , Quantity)

(5) For details of accessories, refer to the individual Instruction Manuals.

(a) Turbocharger
(b) Governor
(c) Filters
(d) Pumps(if motor drive)
(e) Heaters
(f) Centrifuge
(g) Geislinger coupling (if provided)
(h) Remote control device (if provided)
(i) Marine gear（if provide)
(j) Propeller device (if provided)

1.2 Safety Precautions

Most of the accidents arising in handling the engine are caused by the operator's negligence of basic safety rules and precautions or maintenance inspection, etc. as specified by the manufacturer.

Prior to installation, assembly, running, maintenance service and inspection, persons engaged in these items of work should necessarily read through the instruction manual and all other exhibits carefully even for the prevention of danger and use the engine properly after familiarizing themselves with all of the knowledge of plant and equipment, safety information, and cautionary instructions. Besides the above, it is recommended to keep this manual near at hand so that the manual can be referred to at any time in carrying out the work.

“Basic Cautionary Instructions on Safety" in this manual gives a fundamental explanation necessary for securement safety. At the same time, labels gibing warnings to persons concerned are affixed for the prevention of physical accidents caused by mishandling during operation and those caused by inadvertence during maintenance service. It should be noted that the instruction manual and labels have to be followed up as necessary.

The rank of safety precautions is classified into “DANGER", ”WARNING" and “CAUTION" in this instruction manual as shown below.

! **DANGER**	Imminent danger of death or suffering from serious physical injuries.
! **WARNING**	Where possible danger of death or suffering from serious physical injuries, and occurrence of serious physical damage are presumable.
! **CAUTION**	Where possible danger of suffering from light or medium physical injuries, and occurrence of physical damage are presumable.

Even such matters which fall under ! **CAUTION** may possibly lead to serious results depending upon the circumstances. Be sure to observe the instructions given by ! **CAUTION** where every description covers important notes.

1.3 Basic Cautionary Instructions on Safety

1.3.1 General cautionary instructions

Cautions to be used inside engine room and enclosure

- Ventilate the interior of engine room of enclosure.
- Take care against fire, especially observe no-smoking when handling fuel oil and lubricating oil, and keep away from open fire and sparking objects.
- For the prevention of tumbling and upsetting, try to keep orderly arrangement at all times and leave out no articles on the passageway. Always try to keep clean such foothold places as floor surface, foot-plate, etc. that are made slippery and exposed to a danger of tumbling or falling if fouled with oil, water, or the like.
- Make sure of location of passageways and exits so as to take shelter in a safe area forthwith when put in dangerous state in the course of work.

Cautions for garments and protective outfits

- Put on helmet and safety shoes at all times inside the engine room and enclosure.
  When carrying out any work necessitating the Protective outfits (gloves, protective goggles, earplugs, etc.) as listed in “Practical cautionary instructions on safety", be sure to put on specified protective outfits.
- Do not put on any unmatched oversize garments and worn-out clothes. Take off jewels and accessories before starting on work.

Cautions in the course of running

- Where any unusual noise, malodor, or vibration is detected, stop the engine depending upon the circumstances. Clear up the cause and make repairs and restoration before restarting on running.

Cautions in handling outfits

- Use outfits under normal condition at all times and make sure of usage of them before starting on work.
- Make sure that lifting outfits such as chain, hook, rope, etc. are free from abnormalities at any time and observe service criteria and permissible load.
- Hang hooks on the proper positions and use stays necessary.
- Allow slinging and crane operations to be conducted by qualified persons.

Cautions during execution of works

- Prior to repair and inspection work, post a signboard, " NO RUNNING ", on the conspicuous place exposed to view to prevent the engine from being started by mistake during the work.
- When carrying the work by the use of foot plate, manifold, etc. as footholds, it may lead to a serious physical accident caused by falling. To prevent this, give careful attention to footings for the sake of safety.
- Since manual turning of the engine may lead to a danger of serious physical accidents, be sure to carry it out by selecting the proper method and place.
  Never carry out the following.
  - ※ Turning by the use of radiator fan.
  - ※ Turning by the use of starter motor and start air.
- When handling a weighty article exceeding 20kg in weight, use a crane or hoist, or allow two persons or more to engage in the handling work. (In the case of joint work also, the weight should be limited to less than 20kg per person.)
- When handling refrigerants such as liquid nitrogen, put on protective outfits for the prevention of difficulty in breathing and frostbite, and carry out the work in the well-ventilated area.
- When handling combustible substances such as solvent, degreaser, etc., carry out the work carefully in accordance with maker's instruction manual.
- When using compressed air for cleaning etc., put on protective mask and safety goggles.

Cautions in replacement of parts

- Unless our genuine parts are used for replacement of parts, it may result in serious failures and physical accidents. To prevent this, be sure to use our genuine parts.

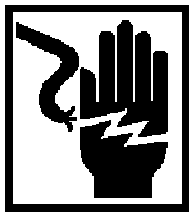
Others

- Do not remodel the engine and plant equipment without our permission.
- Should there be any indistinct points on safety and handling, please contact us.

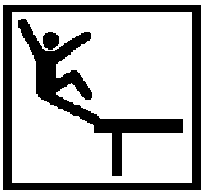
		Remarks
COMBUSTIBLE	1. Equipment and pipelines of fuel oil line, lubricating oil line, and gas fuel line for gas engine.	
	WARNING	
	(1) In cases of fuel leakage from equipment and pipelines of fuel oil line and gas fuel line for gas engine, there is a danger of fire hazard. Conduct inspection at all times to avoid causing bolt looseness, gasket deterioration, and equipment and pipeline cracking.	**6-1 ~ 6-18 7-1 ~ 7-8**
	WARNING	
	(2) In cases of lubricating oil leakage from equipment and pipelines of lubricating oil line, there is a danger of fire hazard. Conduct inspection at all times to avoid causing bolt looseness, gasket deterioration, and equipment and pipeline cracking.	**6-1 ~ 6-18 7-1 ~ 7-8**
	WARNING	
	(3) In case of a possibility of mist-kike leakage due to high pressures in fuel oil line and lubricating oil line, there is a danger of fire hazard. Stop the engine running forthwith and take preventive measures against leakage.	**6-1 ~ 6-18 7-1 ~ 7-8**
	2. Equipment and pipelines of exhaust gas line	
	WARNING	
	(1) In cases of hot exhaust gas leakage from equipment and pipelines of exhaust gas line, there is a danger of fire hazard. Stop the engine running forthwith and take preventive measures against leakage.	**6-1 ~ 6-18 7-1 ~ 7-8**

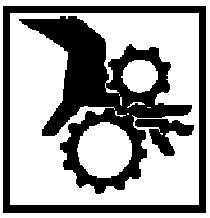
		Remarks
COMBUSTIBLE	3. Anti-freeze **WARNING** (1) Keep away form the fire since anti-freeze entails the danger of ignition to scald.	**3-23** **6-1 ~ 6-24**
EXPLOSION	1. Crankcase door **DANGER** (1) Where the engine is brought to a stop due to abnormal heat generation being detected inside the engine room, there is a danger of explosion if crankcase door is allowed to open forthwith. Open the door after the lapse of a cooling period of not less than 20 minutes.	**6-1 ~ 6-36**
	WARNING (2) There are cases where scald is caused by the actuation of crankcase safety valve due to abnormal pressure rise inside the crankcase. Do not gain access to the blow-off nozzle.	**6-1 ~ 6-36**
	2. Cylinder safety valve **WARNING** (1) There are cases where scald is caused by the actuation of cylinder safety valve due to abnormal pressure rise inside the cylinder. Do not gain access to the blow-off nozzle.	**6-1 ~ 6-36**

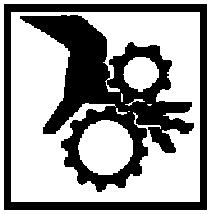
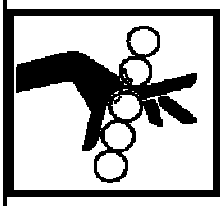
		Remarks
EXPLOSION	3. Exhaust flue safety valve of gas engine **WARNING** (1) There are cases where scald is caused by the actuation of the exhaust flue safety valve of gas engine due to flame failure, etc. Do not gain access to opening of safety valve.	-----
	4. Battery **WARNING** (1) There is a danger of fire hazard due to emission of flammable gas form battery. Keep the surroundings of battery away from the fire.	-----
	5. Engine room for gas engine **WARNING** (1) In cases of gas leakage from gas fuel pipeline, there is a danger of explosion inside the engine room and enclosure for gas engine. To prevent this, be sure to keep the ventilating fan running.	-----
	WARNING (2) In cases where the engine is brought to a stop by the actuation of gas detector, there is a danger of explosion caused by the actuation of gas detector. Close the gas partition valve and turn OFF AC power supply. Thereafter open the doors of engine room and enclosure to effect ventilation thoroughly. After making sure that the concentration of leak gas has come down to the alarm set point or below, carry out the repair work of gas leak location.	-----

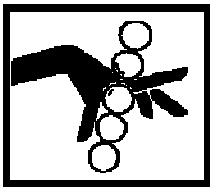
		Remarks
EXPLOSION	**⚠ WARNING** (3) In cases of where an alarm is given by the actuation of gas detector during the period of engine stop, there is a danger of explosion. Close the gas partition valve and turn OFF AC power supply. Thereafter open the doors of engine room and enclosure to effect ventilation thoroughly. After making sure that the concentration of leak gas has come down to the alarm set point or below, carry out the repair work of gas leak location.	-----
ELECTRIFICATION 	**⚠ WARNING** 1. Motor **⚠ WARNING** (1) Each kind of motor entails the danger of electrification. Before turning ON power supply, check if there are any abnormality in wire connections and peel-off of covering.	**6-1 ~ 6-18**
	2. Electrical devices **⚠ WARNING** (1) Electrical devices such as various switches, electrical governor, fuel scale level transmitter, etc. and wiring entail the danger of electrification. Before turning ON power supply, check if there are any abnormality in wire connections and peel-off of covering.	**6-1 ~ 6-18**
	⚠ WARNING (2) Electrical devices built into remote control stand, alarm panel, solenoid valve unit, etc. and separately-installed accessory devices entail the danger of electrification. Before turning ON power supply, check if there are any abnormality in wire connections and peel-off covering.	**6-1 ~ 6-18**

		Remarks
	WARNING	
	(3) Ignition line wiring, booster coil and high tension coil of gas engine entail the danger of electrification due to high voltage being applied to them while the engine is running. Never touch them until the engine has come to a stop. Before starting the engine, check if there are any abnormality in wire connections and peel-off of covering.	-----
POISON	1. Mercury thermometer	
	CAUTION	
	(1) The mercury applied to mercury thermometers is poisonous. Wipe off the mercury spilt from broken thermometers.	-----
	2. Cooling water additives	
	CAUTION	
	(1) The rust-preventive agent, inhibitor and anti-freeze for use with cooling water line are poisonous to the human body. Handle them carefully so that they will not come into eyes or come in contact with the body.	**3-18 ~ 3-23** **7-1 ~ 7-8**
	3. Battery	
	WARNING	
	(1) Battery electrolyte is poisonous. Never allow it to come in contact with skins or come into eyes.	------

		Remarks
SLIPPING	1. Foot plate **⚠ CAUTION** (1) The top surface of foot plate, that is slippery if led with oil etc., entails the danger of tumbling and falling. Wipe off thoroughly the oily matter left on the foot plate and shoes.	**6-1 ~ 6-36** **7-1 ~ 7-90**
	2. Topside of engine **⚠ CAUTION** (1) The topside of engine intake manifold, air dust, etc., that is slippery in some cases, entails the danger of tumbling and falling. Do not step on their topside unless safety has been confirmed.	**6-1 ~ 6-36** **7-1 ~ 7-90**
FALLING 	1. Topside of foot plate **⚠ CAUTION** (1) The topside of foot plate entails the danger of falling. Watch your footing and hold the handrail to the extent possible when moving on the topside.	**6-1 ~ 6-36** **7-1 ~ 7-90**
	2. Topside of engine **⚠ CAUTION** (1) The topside of engine intake manifold, air dust, etc., entails the danger of tumbling and falling. Do not step on their topside unless safety has been confirmed.	**6-1 ~ 6-36** **7-1 ~ 7-90**

		Remarks
ENTANGLED 	1. Flywheel **WARNING** (1) There is a danger of parts of the body being entangled into the flywheel area in the course of engine running. Do not allow your hand, leg, etc. to gain access to the area.	**6-1 ~ 6-36**
	2. Rotating part **WARNING** (1) There is a danger of parts of the body being entangled into the rotating parts (coupling, output shaft, radiator fan, etc.) in the course of engine running. Do not allow your hand, leg, etc. to gain access to the parts.	**6-1 ~ 6-33**
	3. Turning device **WARNING** (1) There is a danger of parts of the body being entangled into the rotating parts or gears of turning device in the course of turning with the turning device. Do not allow your hand, leg, etc. to gain access to the parts.	**6-1 ~ 6-33** **7-1 ~ 7-90**
	DANGER (2) There is a danger of persons, working in the inside and in the vicinity of the engine, being entangled when turning the engine. Carry out the turning operation only after making sure of freedom from danger.	**6-1 ~ 6-33** **7-1 ~ 7-90**

		Remarks
ENTANGLED 	**⚠ WARNING**	
	(3) There is a danger of injuries being caused by contra rotation of crankshaft if turning is carried out without opening the indicator cock or explosion check plug. Be sure to open the indicator cock or explosion check plug when carrying out turning.	**6-1 ~ 6-33** **7-1 ~ 7-90**
	4. When machining	
	⚠ CAUTION	
	(1) There is a danger of hands or legs being entangled during the course of grinding, turning, and drilling work. Do not put on gloves.	**7-1 ~ 7-90**
	1. Moving parts of engine	
	⚠ CAUTION	
PINCHED 	(1) There is a danger of hands or legs being pinched by the moving parts (valve actuator, fuel injection pump roller guide, governor link, stopping piston, etc.) of the engine in the course of engine running. Never insert your hands and legs.	**6-1 ~ 6-33**
	2. Doors of enclosure and engine room	
	⚠ CAUTION	
	(1) There is a danger of your body being pitched by the doors of enclosure and engine room that are designed to be readily closed by the difference in atmosphere between the inside and outside. Take precautions so that your body will not be pinched.	**6-1 ~ 6-33** **7-1 ~ 7-90**

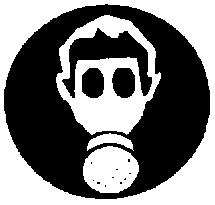
		Remarks
PINCHED 	3. When installing, disassembling and reassembling	
	WARNING	
	(1) There is a danger of your hands being pinched by the gear and cam roller of the engine. Never insert your hands in the course of turning.	**6-1 ~ 6-36** **7-1 ~ 7-90**
	CAUTION	
	(2) There is a danger of your hands and legs being pinched by weighty parts or disassembling tools during overhaul inspection of the engine. Take precautions in handling such parts and tools.	**6-1 ~ 6-36** **7-1 ~ 7-90**
CUTTING/ CUT OFF	1. Fuel injection valve test pump	
	WARNING	
	(1) There is a danger of injuries caused if high-pressure oil droplets come in direct contact with your skins when conducting the injection test of fuel injection pump. Never allow your body to gain access to the range covered by oil droplets. In case where high-pressure oil droplets have come into your body through the skin, then it is necessary to undergo forthwith specialist's diagnosis and surgical treatment.	**7-19**

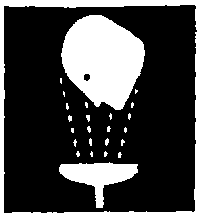
		Remarks
HOT/SCALD	1. Engine **⚠ CAUTION** (1) Since there are many hot parts in the engine during the course of running or right after stopping, there is a danger of scald caused by them. Do not allow your skins to come in direct contact with them. In particular, use extreme care for the following parts that are heated up to high temperatures. ・Exhaust line of the engine ・Indicator cock and cylinder safety valve ・Fuel oil line ・Steam line 2. Inspection or measurement work **⚠ CAUTION** (1) In the case of carrying out the following work, there is a danger of scald caused by high-temperature parts or hot fluid. Put on protective gloves and use care in handling so that hot fluid will not splash over the skin. ・Sampling work of cylinder internal pressure. ・Cleaning of lubricating oil/fuel oil filters. ・When removing the caps of radiator and pressurized fresh water expansion tank. 3. When checking by finger touch **⚠ CAUTION** (1) In the case of checking by finger touch, there is a danger of scald. To prevent this, first allow your finger to approach to the work and make sure that it is not hot, followed by conducting the check by finger touch. If the work is hot, do not conduct the check by finger touch to avoid causing the scald.	**6-1 ~ 6-36** **6-1 ~ 6-36** **7-1 ~ 7-90** **6-1 ~ 6-36** **7-1 ~ 7-90**

		Remarks
SAFETY/ WARNING	1. Control of cooling water, lubricating oil and fuel oil, and control of clamping work **⚠ WARNING** (1) Any negligence of controlling cooling water, lubricating oil, and fuel oil, and controlling the clamping in reassembly after overhaul inspection may lead to fault of the engine and result in physical accidents due to failure of parts. Unfailing control should be conducted on the basis of instruction manual or specifications.	**6-1 ~ 6-36** **8-1 ~ 8-12**
	2. Disassembly work of spring section **⚠ CAUTION** (1) When disassembling the spring section during the course of overhaul inspection, parts are caused to jump out due to disengagement of disassembly tools. Thus, there is a danger of injuries. Familiarize yourselves with the construction of component and use tools properly. Also give care full attention to the jumping direction of parts so that the body will be kept away from the jumping direction.	**7-1 ~ 7-90**
	3. Hydraulic tool and fuel injection valve test pump **⚠ CAUTION** (1) When using hydraulic tools or when conducting the fuel injection valve injection test, high- pressure fluid will gush out , leading to the danger of injuries. Never allow your body to gain access to the range covered by oil droplets. In case where high-pressure oil droplets have come into your body through the skin, then it is necessary to undergo forthwith specialist's diagnosis and surgical treatment. Apply hydraulic pressure only after making sure that joints are securely connected.	**7-1 ~ 7-90** **8-1 ~ 8-12**

		Remarks
SAFETY/ WARNING	4. Engine for auto start or remote start **WARNING** (1) The engine may start abruptly without notice through the auto start signal or by remote starting. As there is a danger of entanglement etc., do not gain access to rotating parts and moving parts. 5. Prevention of miss-starting during maintenance inspection **WARNING** (1) There is a possible danger of physical accidents that may be caused when the engine is started by mistake during the inspection and repair of the battery-started engine. Be sure to carry out the following items to prevent the erroneous start of the engine. ・Disconnection of battery power source. ・Capacitor discharge. **WARNING** (2) There is a possible danger of physical accidents that may be caused when the engine is started by mistake during the inspection and repair of the air-started engine. Be sure to carry out the following items to prevent the erroneous start of the engine. ・Close the main valve of starting air-tank outlet. ・Release the residual pressure remaining inside the starting air pipeline. (Between the starting air tank to the engine)	**5-1 ~ 5-18** **7-1 ~ 7-90** **8-12** ------ **5-1 ~ 5-18** **7-1 ~ 7-90** **8-12**

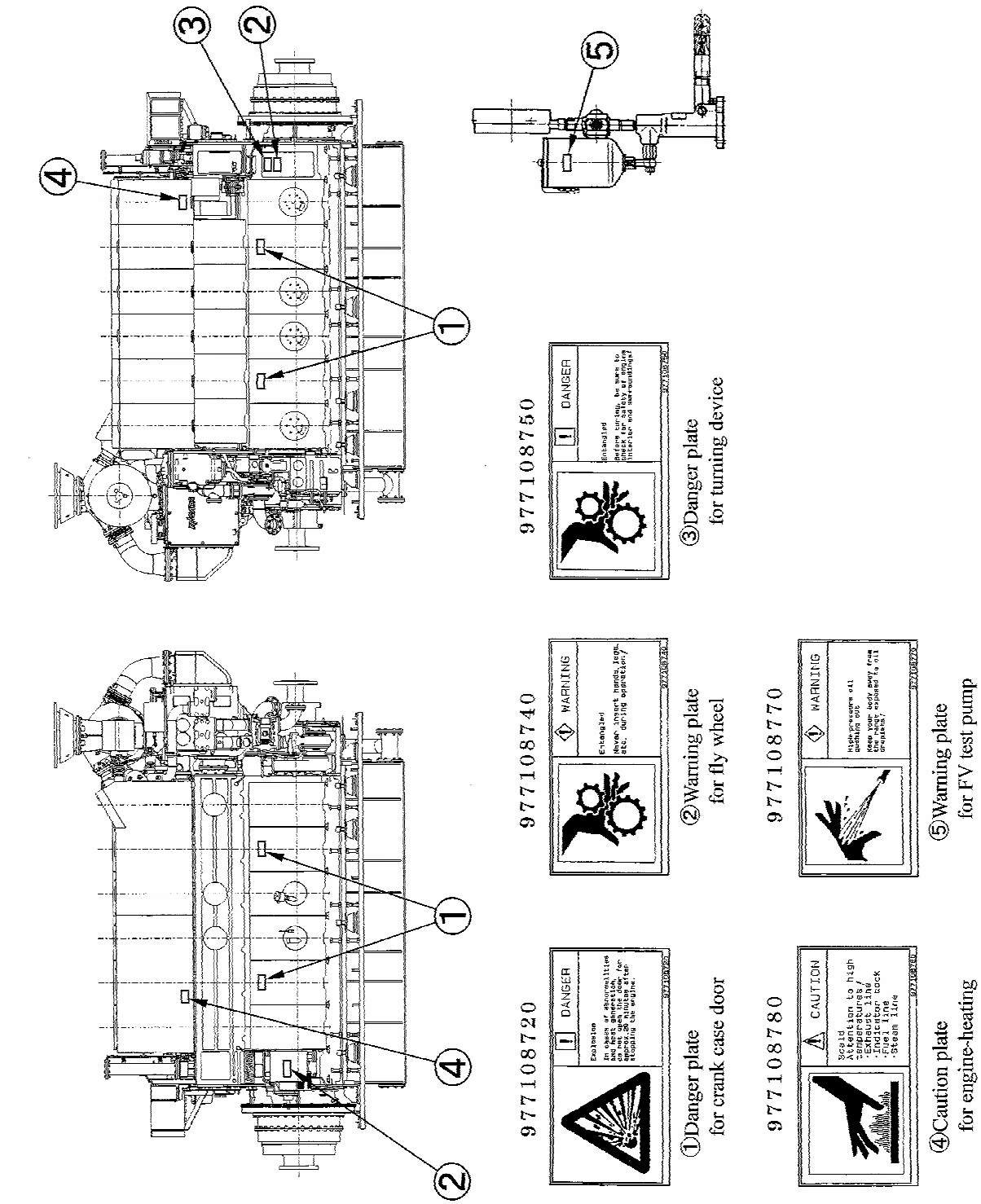
		Remarks
SAFETY/ WARNING	6. Fuel oil **⚠ CAUTION** (1) There is a danger of failure of the engine when gasoline or alcohol is used as a fuel or mixed into fuel oil. Be sure to use the specified fuel oil only.	**3-1 ~ 3-7**
ELECTRO-MAGNETIC WAVE	1. Electrical governor and remote controller **⚠ CAUTION** (1) There is a danger of critical accidents arising From such malfunction of electronic devices applied to electrical governor and remote controller as is caused by electromagnetic wave. Keep away from electromagnetic wave generating equipment.	**5-1 ~ 5-18** **7-1 ~ 7-90** **8-1 ~ 8-12**
PROTECTION OF EYES	1. Work necessitating protection of eyes **⚠ CAUTION** (1) Be sure to put on safety goggles in carrying out the following items of work being in danger of injury to eyes. ・When handling fuel oil, lubricating oil, cooling water and inhibitor, and anti-freeze solution ・In course of washing work ・In course of fuel injection valve injection test ・When handling battery electrolyte ・In course of grinding work ・In course of intake/exhaust valve grinding work	**5-1 ~ 5-18** **7-1 ~ 7-90** **8-1 ~ 8-12**

		Remarks
PROTECTION OF EARS	1. Inside the engine room and enclosure **⚠ CAUTION** (1) There is a danger of hard of hearing caused by noise when gaining access to the inside of engine room and enclosure in course of engine running. Be sure to put on ear plugs.	**5-1 ~ 5-18** **7-1 ~ 7-90** **8-1 ~ 8-12**
PROTECTION OF HEAD	1. Inside the engine room and enclosure **⚠ CAUTION** (1) There is a danger of injury to the head inside the engine room and enclosure. Be sure to put on a helmet for the protection of the head.	**5-1 ~ 5-18** **7-1 ~ 7-90** **8-1 ~ 8-12**
PROTECTIVE MASK 	1. Work necessitating protective mask **⚠ CAUTION** (1) Put on protective masks since the following items of work are in danger of adverse effect upon the health due to inhalation of deleterious mist or dust. ・In course of cleaning work with compressed air ・When handling heat insulation material (glass cloth etc.)	**5-1 ~ 5-18** **7-1 ~ 7-90** **8-1 ~ 8-12**

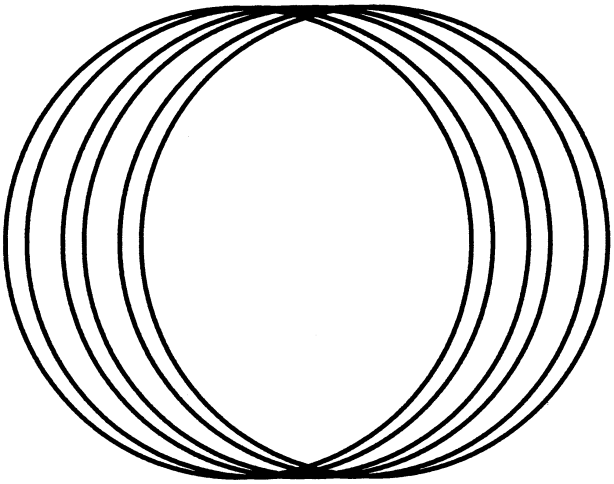
		Remarks
SAFETY SHOES	1. Inside the engine room and enclosure **⚠ CAUTION** (1) There is a danger of injury to your legs during the work inside the engine room and enclosure. Be sure to put on safety shoes for the protection of your legs.	**5-1 ~ 5-18** **7-1 ~ 7-90** **8-1 ~ 8-12**
PROTECTION OF HANDS	1. Inside the engine room and enclosure **⚠ CAUTION** (1) There is a danger of injury to your hands during the work inside the engine room and enclosure. Be sure to put on gloves for the protection of your hands except for the case of special work.	**5-1 ~ 5-18** **7-1 ~ 7-90** **8-1 ~ 8-12**
PROHIBITION OF GLOVES	2. During machining work **⚠ CAUTION** (1) There is a danger of entanglement in the course of grinding, turning and drilling work. Do not put on any gloves.	**7-1 ~ 7-90**
EYE-WASH 	1. Chemicals handling work **⚠ CAUTION** (1) When handling chemicals solution such as inhibitor, battery electrolyte, etc., there is a danger of injuries to your eyes or skins being contaminated with chemicals solution. In cases of contamination, wash your eyes or skins thoroughly with water or soapy water and consult a physician immediately.	**7-1 ~ 7-90**

		Remarks
FIRE EXTINGUISHER	1.Fire extinguisher	
	⚠ CAUTION	.
	(1) In carrying out the work inside the engine room and enclosure, there is a danger of flammable liquid etc. being ignited by welding or electric sparks. Be sure to make a fire extinguisher ready for use during the course of work. When carrying out the work, be sure to install a shielding for the prevention of the danger of ignition.	**6-1 ~ 6-18** **7-1 ~ 7-90**
	⚠ DANGER	
	(1) If the engine fails to start, please discharge the unburned gas from the exhaust system by air running. If the engine restarts without discharging unburned gas, it may cause danger explosion.	**6-1 ~ 6-18**

1.4 DANGER・WARNING・CAUTION PLATE POSITION



MEMO



NIIGATA DIESEL
INSTRUCTION MANUAL
MG(L)28AHX

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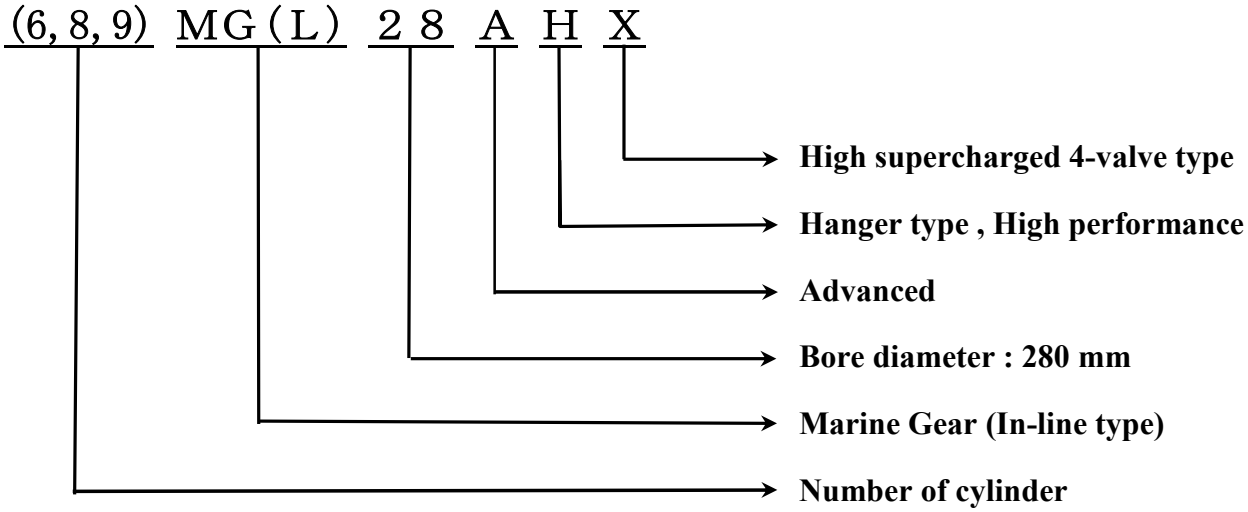
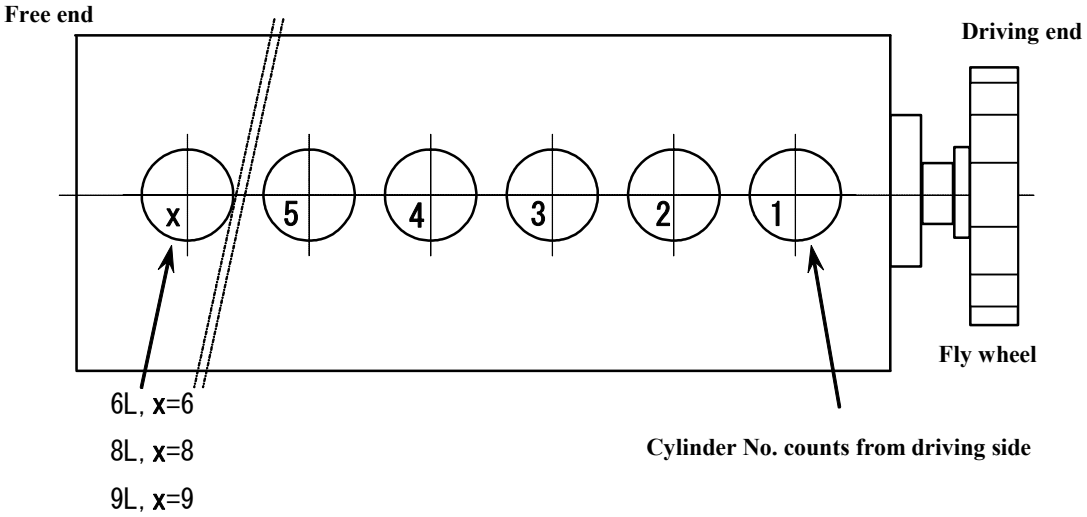
2. GENERAL

2.1 Engine Model


(6, 8, 9) MG (L) 2 8 A H X
High supercharged 4-valve type
Hanger type , High performance
Advanced
Bore diameter : 280 mm
Marine Gear (In-line type)
Number of cylinder

2.2 Cylinders arrangement



2.3 Manufacturer

IHI Power Systems Co., Ltd.

MANUFACTURING PLANT :

OHTA PLANT

No.125-1, NISHISHINMACHI, OHTA-CITY, GUNMA-PREFECTURE, JAPAN

PHONE : +81-276-31-8113

FAX : +81-276-31-8119

NIIGATA ENGINE PLANT

No.1300, OKAYAMA HIGASHI-KU, NIIGATA-CITY, NIIGATA-PREFECTURE, JAPAN

PHONE : +81-25-274-5115

FAX : +81-25-271-5825

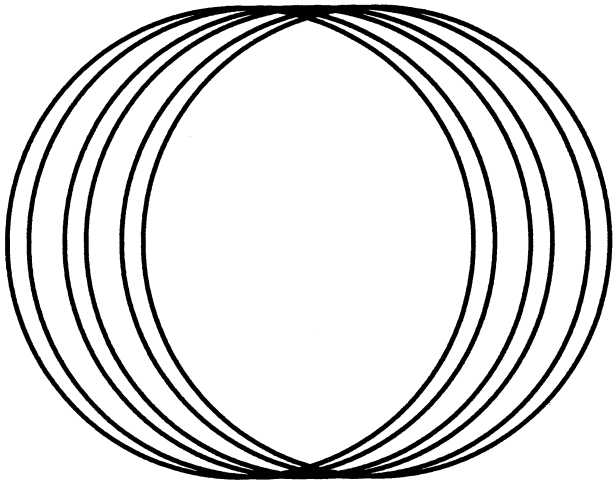
2.4 Engine specification

Model			6MG(L)28AHX	8MG(L)28AHX	9MG(L)28AHX
No. of cylinders			6	8	9
Cylinder bore		mm	280		
Piston stroke		mm	390		
Max. continuous Output		kW	As specified by the application		
Max. Cylinder pressure		MPa	18.0		
Rated speed		min^{-1}	As specified by the application		
Mean piston speed		m/s	As specified by the application		
Swept volume		L	144	192	216
Firing order	Clockwise		1-3-5-6-4-2	1-3-2-5-8-6-7-4	1-3-5-7-9-8-6-4-2
	Counter clockwise		1-2-4-6-5-3	1-4-7-6-8-5-2-3	1-2-4-6-8-9-7-5-3

Rotation direction		Clockwise or Counterclockwise (viewing from driving end side)
Starting system		By compressed air starter system
Lubrication System	System lubricating oil	By an engine driven gear pump＊
	Rocker gear lubricating oil	
	Turbocharger lubricating oil	
Cooling system	Cylinder jacket	By an engine driven water pump＊
	Cylinder head	
	Piston	By cocktail shaking method with system lubricating oil
	Air cooler	By an engine driven water pump. ＊
	Lubricating oil cooler	
	Fresh water cooler	
Fuel oil supply system		By an engine driven trochoid pump＊
Turning device		By a motor driven reduction gear＊
Governor		Electro-hydraulic governor
Turbocharger		Exhaust gas turbocharger
Air cooler		2-stage fin-tube type
Fuel injection pump		Bosch type
Fuel injection valve		Multi-hole self injection type

＊It depends on a specifications.

MEMO



NIIGATA DIESEL INSTRUCTION MANUAL

MG(L)28AHX

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3. CONTROL OF FUEL OIL, LUBRICATING OIL AND COOLING WATER

⚠ WARNING : Any negligence of controlling cooling water, lubricating oil, and fuel oil, and controlling the clamping in reassembly after overhaul inspection may lead to fault of the engine and result in physical accidents due to failure of parts. Unfailing control should be conducted on the basis of instruction manual or specifications.

3.1 Fuel oil

⚠ CAUTION : There is a danger of failure of the engine when gasoline or alcohol is used as a fuel or mixed into fuel oil. Be sure to use the specified fuel oil only.

3.1.1 Fuel oil properties

Specifications of Fuel Oils

Properties \ NES Class				AA	BA	C40A	C180A	C180B	C380B	C380C	C500C	C700C
Kinematic Viscosity	mm^2/s at50℃		max	5.5	20	40	180	180	380	380	500	700
	mm^2/s at100℃			— [*2]	5.4	10	25	25	35	35	45	55
Density	g/cm^3 at15℃		max	0.870	0.920	0.960	0.960	0.991	0.960	0.991	0.991	0.991
Flash Point	℃		min	60	60	60	60	60	60	60	60	60
Pour Point	℃	Winter [*1]	max	0	0	5	15	30	15	30	30	30
		Summer		5	5	5	15	30	15	30	30	30
Carbon Residue	%(m/m)		max	1.3 [*3]	4	10	10	10	15	15	15	15
Water	%(V/V)		max	0.1	0.3	0.3	0.5	1.0	0.5	1.0	1.0	1.0
Ash	%(m/m)		max	0.01	0.05	0.1	0.1	0.1	0.1	0.15	0.15	0.15
Sulfur	%(m/m)		max	1.0	2.0	2.0	2.0	3.5	3.5	3.5	3.5	3.5
Vanadium	mg/kg [*5]		max	0	100	100	100	100	100	300	300	300
Aluminum	mg/kg [*5]		max	0	0	0	0	(30) [*4]	(30) [*4	(30) [*4]	30	30
Silicon	mg/kg [*5]		max	0	0	0	0	(50) [*4]	(50) [*4]	(50) [*4]	50	50
Sodium	mg/kg [*5]		max	0	20	20	20	20	20	60	60	60
Asphaltene	%(m/m)		max	— [*2]	2.5	7	7	7	10	10	10	10
Cetane Index			min	45	— [*2]	— [*2]	— [*2]	— [*2]	— [*2]	— [*2]	— [*2]	— [*2]
CCAI			max	825	835	850	860	860	860	860	860	860
				The fuel shall be free of used lubricating oil.								

*1 Winter : When minimum temperature is equal to or less than +5℃
*2 Not specified
*3 On 10%(V/V) distillation bottom
*4 Not allowable in principle
*5 mg/kg=ppm(m/m)

NOTE : (1)When using high-viscosity oil with a kinematic viscosity of 30 cSt (at 50°C) or over, a specific pretreatment is necessary for heating and purifying the fuel oil.
(2) When using a special fuel oil, which does not satisfy these requirements , contact us to determine its usability.
(3) When using heavy oil, it is desirable for engine maintenance to use a purifier even if its viscosity is low.
(4) Content ratio of Sodium/Vanadium is less than 1/5.

Fuel oil for diesel engines must have good combustibility and produce as few combustion deposits as possible.

The required properties of fuel oil are as follows.

(a) Reaction

It must be chemically neutral, oils of acidity or of alkali may corrode metallic parts.

(b) Density

Generally speaking, fuel oil of higher density may be lower quality (excluding very waxy oil, F.C.C. products and thermal cracking products).

When density increases near to 1.0, water in the fuel is hardly separated in the settling tank and by the centrifugal purifier.

(c) Flash point

It does not directly influence combustion conditions of the engines, but should be taken into consideration at handling the fuels from the point of view of fire protection.

(d) Kinematic Viscosity

Viscosity varies with temperature. When temperature rises, viscosity drops. When burning heavy oil, good combustion is generally obtained if the particles of sprayed oil are uniform and small in size.

The atomization of oil depends largely on its viscosity so it is necessary to heat up the fuel oil to appropriate viscosity(55 - 65 s/RW No.1) suitable to atomization injection pressure. If fuel viscosity is very high, the flow efficiency of the fuel oil from the fuel tank to the fuel injection pumps is low, pump capacity efficiency drops, air bubbles get trapped in the fuel piping, and the fuel is not properly sprayed out of the fuel injector nozzles inhibiting combustion.

If fuel viscosity is too low, the fuel injection pumps and plungers become less lubricated, resulting in early plunger wear, fuel leakage, and nozzle sticking. In addition, poor penetration and dispersion through the fuel nozzles hinder fuel combustion.

(e) Pour point

This value concerns mobilization of the fuel oil, so that, if it is difficult to transfer the oil due to its high pour point the oil has to be heated up over the pour point.

(f) Residual carbon and ash content

Their presence does not directly affect combustion, but these substances hardly burn within the operating temperature range, and remain in the cylinders as deposits which cause faulty operation, piston ring sticking, and accelerate abrasive wear of various parts and the deposits fall into the lube oil, resulting contamination of the lube oil.

(g) Sulfur content

Sulfur is present as a compound of sulfur and high-molecular hydrocarbon.

During combustion, sulfur combines with oxygen at high temperatures to form sulfur dioxide(SO2) in gaseous form. SO2 does not burn, but when exposed to flame temperatures it can combine chemically with additional oxygen, to form sulfur trioxide(SO3). SO3 combines with the water in the oil and intake air and the water produced by combustion in the hydrogen in the fuel oil to form sulfuric acid (H2SO4). This substance causes corrosion and wear of the cylinder liners and piston rings.

Generally, a sulfur content of less than 1□ (weight), won't to be a serious problem. If sulfur accounts for 2□ or more, great care must be taken concerning the lubricating oil to be used.

(h) Water content

Much water causes lowering of calorific value, rusting, and valve sticking. It also combines with the sulfur dioxide and sulfur trioxide to produce various ill effects. Water can be removed to a certain degree by a centrifugal separator.

(i) Cetane Index

Cetane index represents the ignition property of diesel engine fuel oil. It is advisable to select fuel oils with a cetane index of 45 or over, because of difficult starting with lower cetane index fuels.

(j) CCAI（Calculated Carbon Aromaticity Index ）

CCAI represents the aromaticity of diesel fuel oil. This value is used to judge the ignition property of fuel oil. Upper limit of usable range is CCAI 860. If the value overcome 860, hard knocking occurs at low load. Cetane index of 45 corresponds to CCAI 825.

The density and the kinematic viscosity as the below equation determine CCAI value. If use the nomograph, you can determine about CCAI value easily.

— For the nomograph, refer to page 3-6

$CCAI = D - 141 \times \log \{\log (V+C)\} - 81$

D: Density〔kg/m^3,at 15 ℃〕　V: Kinematic viscosity〔mm^2/s,at 50 ℃〕

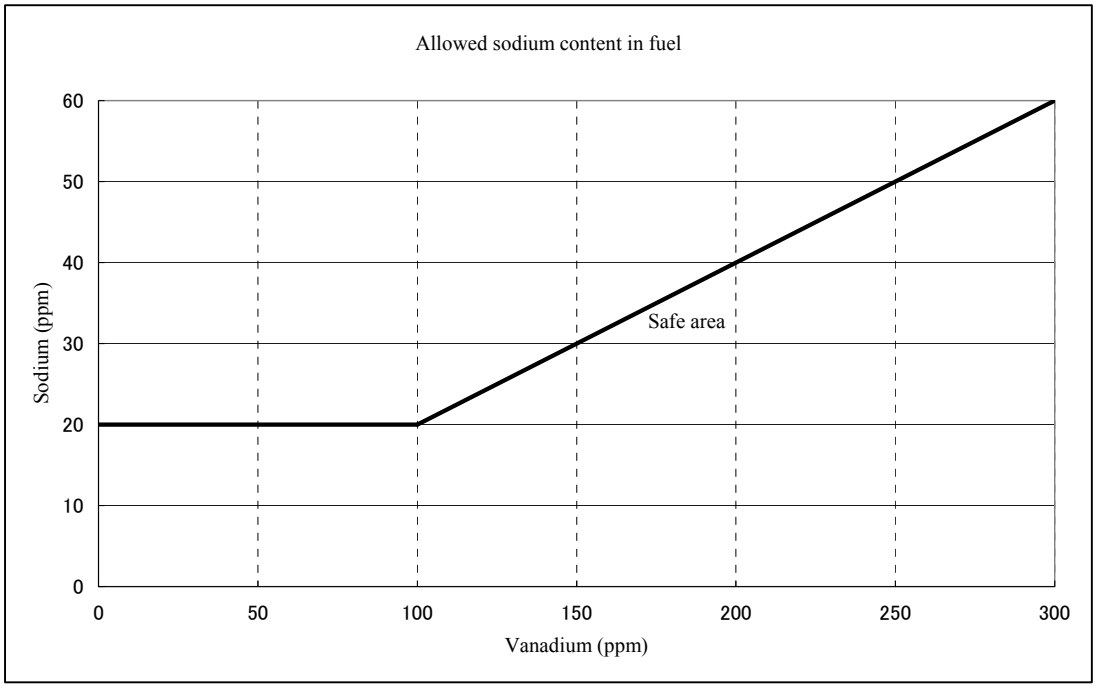
C: Constat 0.85

(k) Vanadium and sodium content

Vanadium content depends on crude oils, high content from VENEZUELA is known. Sodium contributes to hot corrosion on exhaust valves when combined with high vanadium contents. Also Sodium is one of a primary factor for strongly fouling turbine nozzles and blade at high load. If the vanadium content of the fuel is less than 300 ppm, the maximum sodium content is 60 ppm.

The relation between sodium and vanadium content of fuel according to fig. are allowed.

It is recommended to keep sodium content less than 1 / 5 the weight of vanadium.



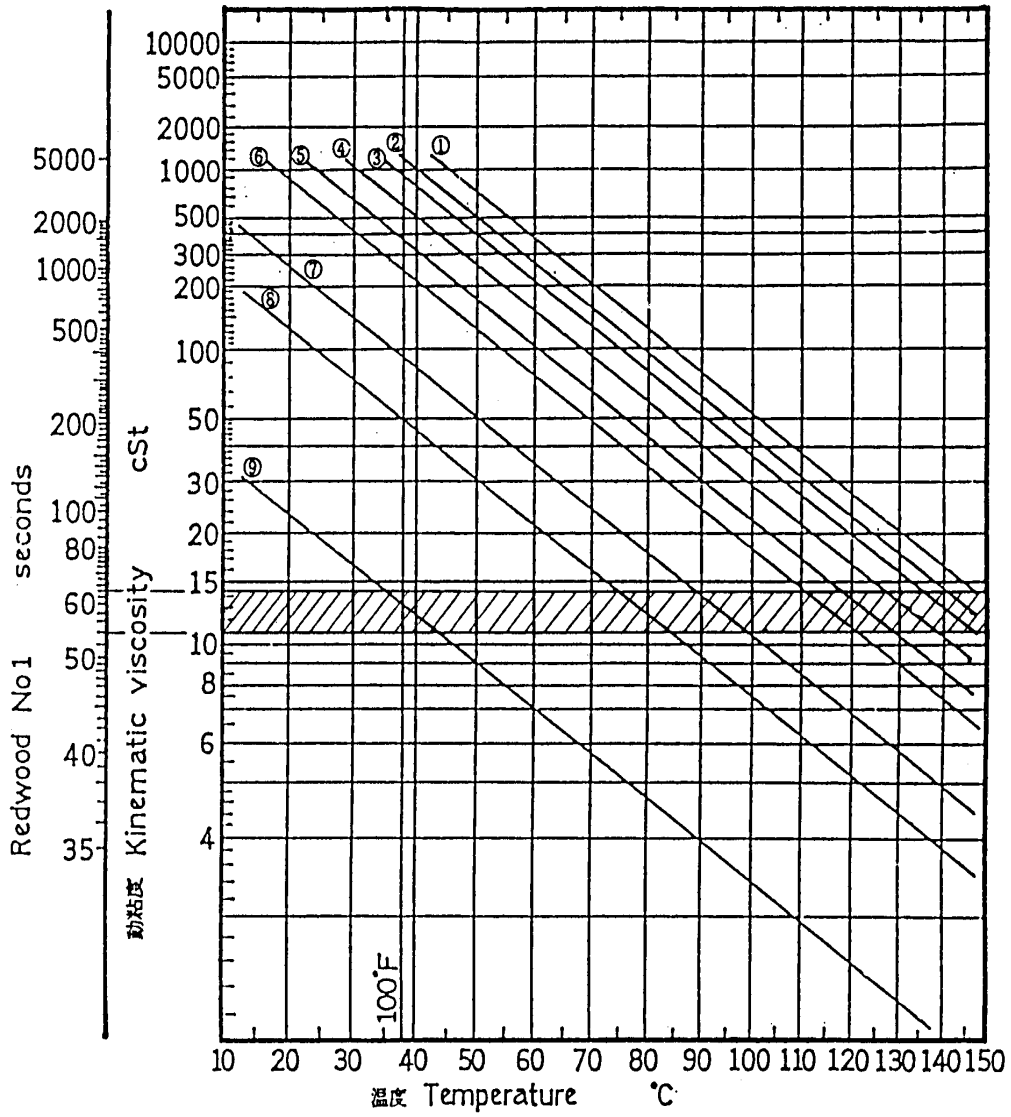
(l) Aluminum and silicon content

Heavy fuels blended by F.C.C. process products contain somewhat particles of aluminum-silica applied as a catalysis in the process.

These particles which are very small (to 100μm) and very hard cause wear of the fuel injection pump (plunger and liner), the fuel injection nozzle, the piston ring, the piston ring groove and the liner etc.

In principle, don't use F.C.C. oil, If cannot help using F.C.C. oil, must use a high performance fine filter due to removes alumina-silica.

Viscosity-Temperature diagram



① 700	④ 250	⑦ 50
② 500	⑤ 180	⑧ 30
③ 380	⑥ 125	⑨ 9

NOTE : Viscosity-Temperature varies in accordance with chemical composition of fuels, therefore, exact values should be obtained by measuring the sample at two or three points.
The following is a conversion equation of °C and °F.

$$C = 5 / 9 \times (F - 32)$$

$$F = 9 / 5 \times C + 32$$

Nomograph for Determination of CCAI and CII

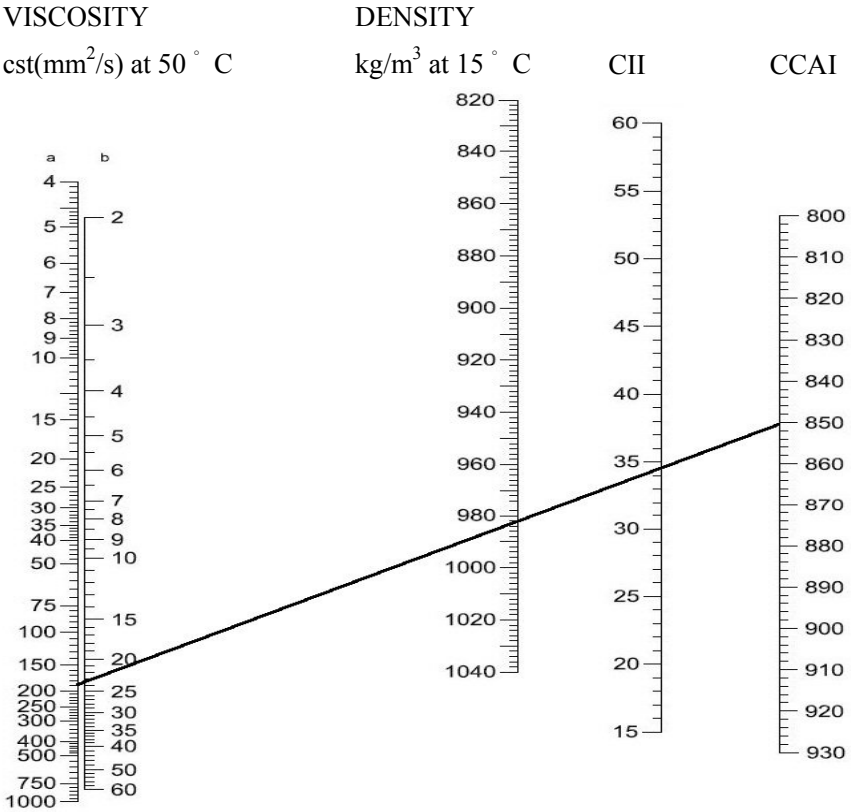
$$CCAI = D - 81 - 141 \times \log [\log (V + 0.85)] - 428 \times \log [(T+273) / 323]$$

$$CII = (270.795 + 0.1038 \times T) - 0.25456 \times D + 23.708 \times \log [\log (V+0.7)]$$

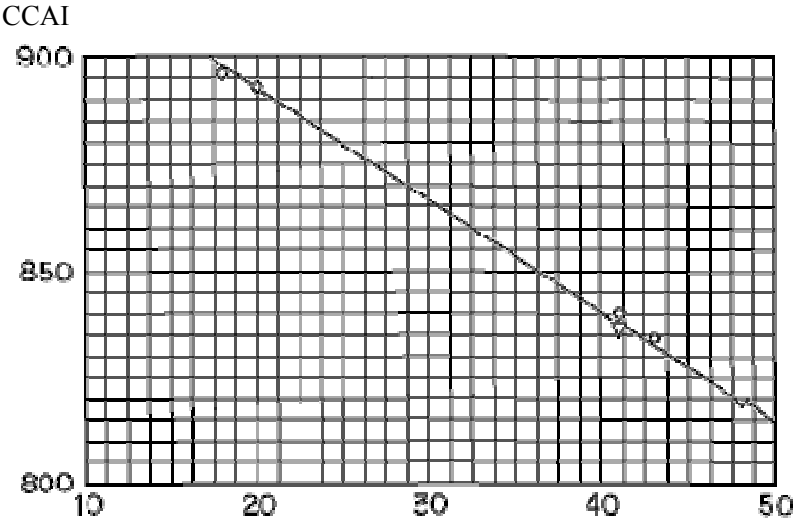
D:Density [kg/m^3,at 15 °C]

V:Kinematic viscosity [cSt (mm^2/s),at 50°C]

T: Temperature (°C)



CCAI-Cetane number diagram



3.1.2 Control of fuel oil

The following precautions must be observed concerning the control of fuel oil.

(a) Fuel oil purchase

Use recommended brand. It is most desirable that the same brand be use always. If the same brand is not available due to service overseas, for example, it is necessary to select a fuel oil having properties similar to those of the fuel oil, which has been used up to, that time.

(b) Precautions in filling the fuel tank

Before filling the fuel tank with a fresh supply of oil, empty the tank if possible. It is desirable that the bottom of the tank be cleaned of sludge, before refilling. When filling a fuel tank that is not empty with a fresh supply of fuel oil, the brand must be the same. Never mix uncertain brands of fuel oil or different brands of fuel oil in the fuel tank in an attempt to prepare a suitable viscosity.

(c) Precautions after filling the fuel tank

Prevent dust, seawater, and other foreign matter from getting into the fuel tank. If the fuel oil is stored for long time in tank, sludge settles in the bottom of the tank due to temperature variations and oil properties, causing problems. Therefore discharge the drains at the bottom of the fuel tank every day.

(d) Other precautions

(d1) Purifier

If the purifier is suspected to be faulty, read its Instruction Manual and check to see if it has been properly used. The purifier may not always operate properly depending on the kinds of fuel oil and the operating conditions of the engine. In that case, ask the purifier manufacturer for advice.

Some of the fuel oil contents can be easily removed, and some cannot. It is desirable for engine maintenance that a large enough purifier be installed if it is technically and possible.

(d2) Fuel oil additives

Fuel oil additives include combustion assistants and emulsion breakers. It is suggested, however, that a fuel oil with properties that require no such additives be selected.

3.2 Lubricating oil

Proper selection and monitoring of the lubricating oil is essential for satisfactory engine performance and life. The lubricating oil must be from a list approved by Niigata for the application and fuel-type being used. All instructions from Niigata and its dealers concerning lubricating oil must be followed to assure warranty coverage.

⚠ **CAUTION** : Be sure to put on safety goggles in carrying out the following items of work being in danger of injury to eyes.
・When handling lubricating oil

3.2.1 Lubricating oil properties

Lubricating oil for diesel engines must have the following properties.

(a) Appropriate viscosity and high viscosity index

(a1) If viscosity is too high, lubricating oil generates heat due to its own resistance, causing bearing temperature rise and power loss. If viscosity is too low, on the other hand, oil film becomes thin, causing metal-to-metal contact and possibly increased lubricating oil consumption.

(a2) Because the temperature inside the engine differs greatly at start up and during operation, a high viscosity index is required.

(b) Excellent detergent dispersion quality

(b1) The property of the lubricating oil which disperses unburnt carbon, the ash produced by combustion, and the sludge generated by heating and oxidation into the lubricating oil as fine particles instead of letting them aggregate in the oil is called dispersion quality. It is generally called detergent dispersion quality because it prevents such substances from sticking to piston heads, piston rings, and ring grooves, and settling inside the engine, and thereby keeps the inside of the engine clean.

(b2) Detergent dispersion quality can be improved by adding a detergent dispersion improver to lubricating oil. If the engine burns residual oil, or is high-powered with a turbocharger, or is operated under severe conditions, a lubricating oil with excellent detergent dispersion quality must be used.

(c) Excellent acid neutralizing quality

If the sulfuric acid generated by the sulfur content of fuel oil drops onto the oil pan, and is carried to various parts of the engine by the lubricating oil, it causes corrosion. Particularly if seawater gets in, the sulfuric acid reacts to the salt contained in the seawater to generate hydrochloric acid, which is still more corrosive. A powerful acid neutralizing quality is required to prevent corrosion by sulfuric acid and hydrochloric acid, which are extremely harmful to the engine.

(d) Excellent heat stability

When exposed to high temperatures, lubricating oil is decomposed by heat to produce carbon. Because the backs of the piston heads in a diesel engines will reach nearly 200°C, the lubricating oil used for lubrication and cooling must have high stability at high temperatures. Lubricating oil with poor heat stability produces carbon deposits with cause ring sticking, cooling inefficiency, and piston head cracking. Lubricating oil with poor heat stability produces carbon deposits with cause ring sticking, cooling inefficiency, and piston head cracking.

(e) Excellent oxidation stability

Lubricating oil changes its quality through oxidation reaction induced by the oxygen in the atmosphere. This oxidation quickens in reaction speed as the temperature rises. It is generally said that reaction speed increases two-fold as the temperature rises 10°C.

If water or metal dust gets into lubricating oil, it acts as a catalyst to quicken the reaction. When lubricating oil is oxidized, the viscosity increases and the color phase grows worse. In the meantime, black sediment(sludge) collects in the bottom of the oil pan, and part of the sludge may be carried away to stick to be bearings or settle around them, or clog the oil passages to cause bearing seizure.

If sludge is deposited around the cylinder liners or piston rings, it causes ring sticking, oil scraper ring groove blocking, increased wear, and piston or liner seizure (due to poor heat transmission). Add an anti-oxidant to prevent lubricating oil oxidation.

(f) Anti-rusting quality

The cooling water can accidentally get inside the diesel engine. If lubricating oil has no anti-rusting quality, the cooling water may be carried with the lubricating oil to various parts of the engine to generate rust.

(g) Excellent water separation quality

If water gets into the lubricating oil, it must separate quickly from the oil. Lubricating oil with poor water separating quality gets emulsified by water, which not only changes its quality soon but causes rusting, wear, and seizure.

(h) Excellent anti-foaming quality

An excellent anti-foaming quality is another important requirement for lubricating oil. Lubricating oil with foam can cause bearing trouble and serious pressure gauge misreading.

(i) High flash point

It is desirable that lubricating oil has high flash point because it is exposed to the hot parts of pistons, etc.

(j) Low pour point

A pour point is the standard of the right or wrong of the ability to transfer the pump of the lubricating oil to use in cold districts and the winter. When the minimum temperature become lower than a pour point, the piping, the tank and so on need heating equipment.

3.2.2 Lubricating oil selection

Because of the great effect of heat and combustion deposits, these must be carefully taken into account in selecting a lubricating oil for the diesel engines.

(1) Selection standard

(a) Trunk piston type(engine construction)

In the case of the trunk piston type, lubricating oil is directly affected by blow-by, and can be easily mixed with combustion deposits, carbide and sludge produced by exposure of the oil itself to high temperature gas, and metal dust from the rings and liners.

Therefore, it is necessary to select a lubricating oil having anti-oxidation properties to prevent oxidation of the lubricating oil itself and oxidation caused by foreign substances, and excellent detergent dispersion quality to remove combustion deposits, which are liable to settle on the liners and in the ring grooves, and to disperse them in the oil.

(b) Piston cooling type

In the case of piston cooling type, part of the cooling oil is thermally decomposed to produce carbides, which combine with sludge to form deposits on the piston cooling surfaces, thereby seriously affecting cooling and causing piston head cracking. It is necessary, therefore, to select a lubricating oil having excellent heat stability.

(c) Fuel oil

(c1) Use of low-cost, residual fuel oil for the engine may be desirable from the standpoint of economy. But fuel oil of lower quality causes greater wear to the cylinder liners and piston rings, more ring sticking, and more adhesion of carbon and other impurities to the sides of the pistons, ring grooves, and intake and exhaust valve ports. These are caused by foreign matter in the fuel oil; hard carbon and ash produced by burning fuel oil and lubricating oil; and sulfuric acid produced by burning the sulfur contained in the fuel oil. Apart from such countermeasures as purifying the fuel oil, and improving the material and shape of the cylinder liners and rings to cope with this problem, it is important to select a suitable lubricating oil.

(c2) Corrosion and wear by sulfuric acid can be effectively prevented by high-temperature cooling with fresh water and then raising the temperature of the cylinder liner walls. If seawater cooling must be used, some condensation of sulfuric acid cannot be avoided because the cooling water temperature cannot be raised so much to prevent scale formation in the water jackets. This is especially so in the case of the main engines for fishing boats that is kept in continuous operation at low load.

In that case, it is necessary to select a lubricating oil having an acid neutralizing quality to positively neutralize the condensed sulfuric acid.

Lubricating oil with a total base number can effectively prevent corrosion and wear because an acid neutralizing agent is added to it.

The standard total base number is mentioned in **3.2.2 (2)**.

(d) Operating conditions

Lubricating oil will seriously deteriorate due to imperfect combustion if the engine is operated at low load, or high load, or if engine load varies considerably. Thus a lubricating oil with excellent anti-oxidation and detergent dispersion qualities must be selected.

(e) Lubricating oil purifier

If a purifier is installed, its type and capacity are among the conditions that must be taken into account in lubricating oil selection.

(2) Kinematic viscosity and total base number

(a) Kinematic viscosity

Lubricating oil of SAE40 viscosity must be used for this engine.

⚠ CAUTION	**USE SAE40**
	But when use in the cold condition, admit to use SAE30. In that case, lower the lubricating oil temperature at the inlet of engine 5 - 10°C because oil film thickness keeping.

(b) Total base number(abbreviated to T.B.N) mgKOH/g

(b1) Select a total base number suitable to the properties of the fuel oil used.
A T.B.N holding standard is determined by the sulfur content of fuel oil and consumption (that is, the absolute quantity of sulfur generated).

(b2) A higher T.B.N is not necessarily better. If its main constituents of calcium and barium are combined with acid, no problem will arise; but if they are not (in case sulfur content is small relative to T.B.N), combustion deposits (residual carbon and ash) generated by combustion accelerate wear. If combustion is imperfect, the viscosity will increase so much that the exhaust manifold may be adversely affected. Actually, T.B.N should be considered on a case by case basic according to the rated output power, operating conditions, and fuels consumption of the engine. Here is a standard for your reference.

Recommended brands based on the above selection standard shown next page.

NOTE : (1) When using other than the recommended brands, contact us to determine the usability of your selected oil.
(2) Avoid mixing different brands.

Table 1 Medium speed diesel engine (Marin use , Land Use) Recommend brands of SAE40 viscosity

If Pmax is more than approximate 13MPa, the marked "※" oil have to be used and have to be equipped the centrifugal oil.

The figure in ( ) means TBN of lubricating oil.

Fuel oil [NES class]	Bold box shows the recommended range of lubricating oil for each classified fuel. The figures in [ ] mean the lower limits of total base number(TBN) control condition in service.					
Kerosene ,Diesel fuel	〔50% min. of New Oil TBN and 8 min. of TBN〕			Permissible if necessary		
AA	(Conference)	〔50% min. of New Oil TBN and 10 min. of TBN〕			Permissible if necessary	
BA,C40A,C180A (S=2.0)			〔50% min. of New Oil TBN and 20 min. of TBN〕			Permissible if necessary
C180B,C380B,C380C,C500C,C700C (2.0＜S≦3.5)					〔50% min. of New Oil TBN and 20 min. of TBN〕	
C500H,C700H (3.5＜S≦5.0)						〔25 min. of TBN〕
Maker TBN	10	15	20	25	30	40
Idemitsu Kosam Co., Ltd.	Daphne Marine Oil SX-40(12)	————	Daphne Marine Oil SW-40(20)	Daphne Marine Oil MV-40(25)※	Daphne Marine Oil SA-40(30)※	————
Shell	GADINIA OIL 40(11)	————	————	————	ARGINA T OIL 40(30)※	ARGINA X OIL 40(40)※
EXXON MOBIL	————	MOBILGARD 412(15)	————	————	MOBILGARD M430(30)	MOBILGARD M440(40)
Chevron (Chevron, Caltex and Texaco)	TARO 12XD40(12) DELO 1000 Marine40(12)	————	TARO 20DP40(20)※	————	TARO 30DP40(30)※	TARO 40XL40(40)※
Castrol(BP)	————	MHP154(15) "#"	TLX Plus 204(20)	————	TLX Plus 304(30)	TLX Plus 404(40)
TOTAL	DISOLA M4010(10) DISLOA M4012(12)	DISOLA M4015(15)	DISOLA M4020(20) AURELIA TI 4020(20)	————	AURELIA TI 4030(30)	AURELIA TI 4040(40)
INDIAN OIL	SERVO MARINE C 104(10) SERVO ULTRA 40(10)	————	SERVO MARINE C 204(20)	————	SERVO MARINE C 304(30)	————
PETRON CORPORATION	————	PETROMAR 1540(15)	PETROMAR 2040(20)	————	PETROMAR 3040(30) PETROMAR TPO 40(30)	PETROMAR 4040(40)
PERTAMINA	————	————	SALYX 420(20)	————	SALYX 430(30)	SALYX 440(40)

(NOTE) If turbocharger is NHP or MAN diesel, lubricating oil use recommend brand.

"#" mark : When the marked "#" oil will be used contact with NIIGATA.

3.2.3 Lubricating oil for governor

Lubricating oil for governor is selected from the following.

Refer to the individual instruction manuals for lubricating oil recommendations for the individual accessories.

Lubricating oil viscosity	Remark
SAE10～SAE40	Refer to the Instruction Manual for governor

3.2.4 Lubricating oil change

Lubricating oil should be laboratory analyzed at 500 hour intervals for viscosity, Total Base Number, detergent dispersibility, moisture, and impurities.

The results of the laboratory analysis should be recorded so that changes in the oil properties can be traced as function of engine operating hours. For those engines that accumulate hours rapidly, it is also recommended that on-site analysis of the oil condition be conducted every 100 hours.

(1) Lubricating oil change time judging method

(a) Ask the lubricating oil maker to analyze your oil and determine whether it can be used or not.

(a1) Normally, 1000cc(1 liter) of oil is enough for the purpose.

(a2) It is desirable that the following data be attached to the sample oil.

Customer	Customer's name	
	Use	
Engine	Engine model	
	Serial No.	
	Output	(kW)
	Operating speed	(min-1)
	Delivery	
	Cumulative operating	
Fuel oil	Diesel oil / heavy oil / residual oil	
	Fuel supplier	
	Use of purifier Cleaning interval / Overhaul interval	

Lubricating oil	Supplier / Brand	/
	lubricating oil consumption	L/day
	Use of purifier Cleaning interval / Overhaul interval	/ h
	Hour of use	h
	Oil change interval	h
	Lubricating system	Wet / Dry
	System oil quantity	L
	Operating temperature	°C
	Sampling point	
	Sampling date	
Remarks		

(b) Judge by the spot testing method (Spot testing kit is option part)

Although it is best to ask the oil maker to analyze your lubricating oil to determine its further usability, this cannot be down in urgent cases where time is limited. There is also a spot testing method for judging the residual T.B.N detergent dispersion quality, and contamination of the oil with relative ease. By this method, the oil properties can be determined approximately in 10 or 15 minutes without special equipment.

(b1) Testing method, reagent, and judging standard vary with oil makers. Ask your oil maker for detailed information.

(b2) If the spot testing method cannot determine the usability of your oil, it would be safer to change the oil.

NOTE : (1) When sampling lubricating oil, always sample it from the same place, but not the first portion that runs out. Don't take a sample from the oil sump. Otherwise, the wrong judgment might be made on the overall properties of the oil.

(2) Record the data at the time of sampling so they may be referred to later on for control purposes.

(2) Evaluation of properties at limits of use

(a) Flash point

The purpose of measuring the flash point is to prevent explosion accidents inside the crankcase due to fuel oil dilution.

(b) Viscosity

Viscosity generally increases with use. If it has decreased, it is perhaps due to the following:

- Dilution by fuel oil;
- Large quantity of fresh oil added;

Viscosity increase is generally due to the following:

- Contamination by oil drops from cylinders;
- Oxidation
- High-viscosity oil added
- Viscosity can increase even when water gets into the lubricating oil.

(c) Water

There may be various causes of water getting into the lubricating oil. Generally, faulty gaskets on the cylinder jackets and leakage from the oil cooler are probable sources. Care must be taken against seawater leaking into the lubricating oil because it poses a rust problem.

(d) Total acidity

Total acidity is important for straight oil and premium oil. An increased total acidity is caused by oil oxidation or contamination due to oil drops from the cylinders. Care must be taken to prevent it because it can seriously affect the bearings. Total acidity is expressed by potassium hydroxide(KOH) in milligrams for neutralizing all acid components contained 1(one) gram oil.

(e) Strong acidity

The strong acid in system oil is the sulfuric acid produced by combustion; hydrochloric acid will also be produced by seawater leaking into the oil. The strong acid causes engine troubles, such as corrosion to the crankshaft journals and pins, and produces milky spots on chromeplated liners or causes their surfaces to peel. Therefore, no strong acidity should be analyzed.

(f) T.B.N

When using HD type oil, its T.B.N must be measured. If HD type oil is used as system oil, a decreased T.B.N makes the oil useless. So pay attention particularly to its T.B.N, and if its T.B.N has decreased, either change the oil or add fresh oil as appropriate. A decreased T.B.N below the allowable limit virtually makes the acid neutralizing and detergent dispersion properties useless.

(g) Salt reaction

Salt reaction is a very important factor as mentioned in the paragraph on water content. If seawater gets into the lubricating oil, it must be changed.

(h) N-Pentane, toluene insoluble matter

Insoluble matter is an important element for judging system oil deterioration and contamination. Two different kinds of solvents, which differ in dissolving power, specifically N-Pentane and toluene are used. The effects of the insoluble matter of the solvents are as shown in the table below.

N-Pentane	Toluene	Observation
A little	A little	Contamination by insoluble matter is small
Much	A little	Oil is oxidized
Much	Much	Much contamination by carbon and inorganic substances.
Very Much	Much	Oil oxidized, and much contamination by carbon and inorganic substances.

N-Pentane insoluble matter can be reduced mainly by cleanliness control on carbon substances, soil, metal dust, etc.

(3) Precautions in changing lubricating oil

Careful observes the following precautions when changing lubricating oil.

(a) lean the oil sump and the inside of the engine as thoroughly as possible before filling with fresh oil. If the old oil remains or if the inside is dirty, the fresh oil will soon deteriorate in performance, and the detergent property of the new oil washes sludge out, possibly clogging the pipes and filters.

(b) When adding oil, be sure to add the same kind.
Because lubricating oil has various additives, mixing different kinds may emulsify the mixture or produce sediment, making the oil unusable.

(c) When changing or adding oil, be careful not to let in impurities and rags.

NOTE : (1) When lubricating oil consumption is less, the fresh oil added is less and then oil has more stress at early stage.
In this case it is recommended to shorten the oil change interval.
(2) The best way to determine them is to have the lubricating oil analyzed by the oil maker or supplier in every month.

Lubricating oil changing standard

NES Class *		AA.AB		C40A,C180A,C180B, C380B,C380C,C500C, C700C,C500H,C700H		Remark
Kinematic Viscosity@40℃ [mm/s^{2}]		New Lubricating oil -20～+30%		New Lubricating oil -15～+30%		
Flash Point [℃]		Min.160℃				
Total Base Number(TBN) [mgKOH/g]		Refer to the Total base number changing standard				
		Not specified				
Total Acid Number [mgKOH/g]		Not specified				
Strong Acid Number [mgKOH/g]		Not specified				
Water [%]		Warning	Limit	Warning	Limit	
		0.1	0.3	0.1	0.3	
Insolubles [%]		Warning	Limit	Warning	Limit	
	(1) Pentane	1.0	1.5	1.0	1.5	
	(2) Toluene	0.8	1.0	0.8	1.0	
	(1)-(2)	Not specified				

Total Base Number changing standard

NES Class *	Sulfur (S)%	Total Base Number (TBN)	Remark
AA	S<=1.0	-50% New Oil and TBN 10 more	
BA,C40A,C180A	S<=2.0	-50% New Oil and TBN 15 more	
C180B,C380B, C500C,C700C	2.0<S<=3.5	-50% New Oil and TBN 25 more	
C500H,C700H	3.5<S<=5.0	TBN 25 more	

⚠ **CAUTION :** Be sure to put on safety goggles in carrying out the following items of work being in danger of injury to eyes.
- When handling cooling water

3.3 Cooling water

Seawater or fresh water may be used as cooling water. Whichever is used, the water must be kept free of mud and foreign matter.

When using seawater, it is necessary to periodically check the cooling water passages because scale adhering to them will adversely affect the cooling of the cylinder heads in particular, possibly causing cracks in them.

And when using fresh water, observe to the following selection standard.

3.3.1 Cooling water (primary water) selection standard for fresh water cooling

It is very important to be careful of the quality of the cooling water used for the engine. Even if fresh water is used for engine cooling, its dissolved substances can corrode the cooling water system, or cause scale or slime trouble. Corrosion of the engine cooling water system is generally caused by various kinds of chlorides, typical of which is chloric ion (Cl).

Other elements by which to judge the corrosiveness of cooling water are pH, electrical conductance, M-alkalinity, and ammonia. Scale trouble mostly occurs due to calcium(Ca) and magnesium(Mg) in the cooling water, which lower the cooling effect of each cooler and cause cracking in the high temperature parts of the cylinder head.

Attention must be paid to ammonia content because it corrodes the aluminum-copper alloy tubes of the coolers. In addition, silica(SiO_2), manganese(Mn), and iron(Fe) must also be borne in mind as substances causing formation of hard scale. It is necessary for satisfactory operation of the engine over a long period of time to analyze its cooling water and thus determine its suitability as such.

If it is found by analyzing the primary water that it is free of sand, mud, and floating particles, and is colorless and odorless, and if the water quality analyzed values are less than those shown in the table below, it can be used as cooling water.

Water quality standard

No.	Item	Unit	Recommended values
1	Turbidity		＜ 10
2	PH(25°C)		6 ～ 8.5
3	Conductivity (25°C)	$\mu\Omega^{-1}$／cm	＜ 400
4	＊Chemical oxygen demand(COD)	ppm	-
5	M-alkalinity ($CaCO_3$)	ppm	＜ 140
6	Total hardness ($CaCO_3$)	ppm	＜ 80
7	Chloric ion($C1^-$)	ppm	＜ 100
8	Sulfuric acid ion(SO_4^{2-})	ppm	＜ 150
9	Ammonia ion(NH^{4+})	ppm	＜ 10
10	＊Sulfuric ion(S^{2-})	ppm	-
11	Hydrogen sulfide(H_2S)	ppm	＜ 10
12	Total iron(Fe)	ppm	＜ 0.3
13	Silica(SiO_2)	ppm	＜ 50
14	Total residue on evaporation	ppm	＜ 400
15	＊Ignition residue	ppm	-
16	＊Dissolved oxygen	ppm	-
17	Manganese	ppm	＜0.2

The items with the mark ＊ are necessary when making a water quality analysis.

NOTE：

(1) Trouble due to cooling water occurs from the combined effects of dissolved substances, cooling water temperature and cooling water flow rate so that technical data below the values shown in the table above is no guarantee for absolute freedom from trouble. You are advised, therefore, to observe the following instructions, and inform us of the results of your analysis so that the suitability of cooling water may be determined by discussion between us.

(a) Be sure to add a corrosion inhibitor to the circulating cooling water system.

(b) Also use a scale inhibitor depending on the kind of corrosion inhibitor used.

(c) Circulation of the cooling water thickens the substances dissolved in it through evaporation and spraying so replace it with fresh water.

(d) After the first six to 12 months of engine operation, check the hot part of the engine (cylinder heads, cylinder liners) for scale adhesion, and the various parts of the cooling water system for corrosion, and select the optimum water quality control method.

(2) Distilled water or rainwater cannot be directly used as cooling water because of corrosion. In case one of them must be used, either adjust its hardness to more than 30 ppm, or add an inhibitor to it.

3.3.2 Cooling water (primary water) treating additives

Corrosion of the cylinders and the liners of diesel engines cooled by fresh water are generally said to be cavitation or galvanic corrosion. Such corrosion can be prevented by adding a cooling water inhibitor to the cooling water so that a powerful, steady protective film is formed over the metal surfaces to protect them.

Because of waste water control against water pollution and the possibility of increasing corrosion by wrong use, it is necessary in using an inhibitor that to talk with the inhibitor manufacture to decide upon correct use.

(a) Kinds

The following three kinds of inhibitors are generally used.

- Nitrite inhibitor ----- This inhibitor is used because it is not toxic, but is subject to COD control when water containing it is discharged.
- Phosphate inhibitor ----- Because this inhibitor has no toxicity at all, it can be discharged as it is. But it is necessary for the used water to be alkaline.
- Silicate inhibitor ----- Because this inhibitor has no toxicity at all, it can be discharged as it is.

COD : If waste water is added to fresh water (or seawater), the oxygen in the water is reduced so that the water will be depleted of oxygen. The required amount of oxygen is expressed in COD-( )ppm in order to prevent oxygen shortage. The COD requirement can be satisfied by dilution with water, or blowing air into the water, or adding a suitable oxidizer to the water.

(b) Precaution for use

⚠ **CAUTION**
- The rust-preventive agent, inhibitor and anti-freeze for use with cooling water line are poisonous to the human body. Handle them carefully so that they will not come into eyes or come in contact with the body.
- Be sure to put on safety goggles in carrying out the following items of work being in danger of injury to eyes.
- When handling cooling water

(b1) Inhibitor adding method, concentration control, and waste liquid treatment vary form one inhibitor manufacture to another so contact the inhibitor manufactures for advice before using inhibitor.
Generally, a solution of about 10 to 20% by volume is prepared, and is gradually added to the cooling water. If it is used together with an anti-freeze, make sure that the inhibitor and anti-freeze will not adversely affect each other.
If the concentration is incorrect, it may cause corrosion so it is necessary to control inhibitor concentration according to the inhibitor manufacturer standard. Concentration control instruments are available from inhibitor makers.

(b2) Observe the following precautions because intrusion of air into the cooling water will increase the amount of dissolved oxygen and accelerate corrosion.
- Be sure to install air vents at points where air is likely to collect.
- Let the fresh water expansion tank have a certain amount of head (more than 5 m above the axial center of the engine) to control evaporation by the rise of cooling water pressure.
- Use suitable partitions inside the fresh water expansion tank to prevent the cooling water from being unsteady.

(b3) When use zinc plated pipe with cooling water system, don't use nitrite inhibitor.

Brands of cooling water additives

CLASIFCATION	BRAND	MANUFACTURE	CONCENTRATION (ppm) (1)
Non-Nitrite type	DISTILLAN-RR	EXENO YAMAMIZU CORPORATION TEL 03-5201-4651	200～300
	SHADAN K	Otsuka Chemical Co.,Ltd TEL 03-5297-2727	20000
	BLUE COOL S	JX Nippon Oil & Energy Trading Corporation TEL 03-6803-8130	40000～70000
Nitrite type	AQUAS CHELATE D-801L	AQUAS CORPORATION TEL 03-3783-4857	6000～9000
	AQUAS DYNA CG-580		6000～9000
	ORGAFILM C-3 ORGAFILM C-3S	ORGANO CORPORATION TEL 03-5635-5214	C-3:2000～3000 C-3S:4000～5000
	POLYCRIN I-175	KURITA WATER INDUSTRIES LTD. TEL 03-3347-3433	8000～12000
	KURILEX L-109		8500～12000
	KURILEX L-209		8500～12000
	HIMOL AM-5	Taiho Kozai Industries Co.,Ltd TEL 03-6414-5600	1000～3000
	HIMOL L-10		8000～12000
	NEOS PN-106 PN-106S	NEOS CORPORATION TEL 078-331-9381	106:2000～3000 106S:8000～12000
	NALCO 39M	Nalco Company TEL 06-6321-7306	15000
Long-life Coolants	APOLLO RADIATOR COOLANT	Apolloretailing Co.,Ltd TEL 03-5575-0302	300000～600000
	SHADAN A SHADAN AB	Otsuka Chemical Co.,Ltd TEL 03-5297-2727	150000～300000
	KYGNUS LONG LIFE COOLANT	Kygnus Sekiyu K.K. TEL 03-3276-5255	300000～500000
	COSMO LONG LIFE COOLANT	COSMO TRADE & SERVICE CO.,LTD TEL 03-5462-2801	300000～600000
	LC SUPER SINKAITYOU	CCI CORPORATION TEL 0575-24-4844	300000～600000
	SUPER COOLANT X	JX Nippon Oil & Energy Trading Corporation TEL 03-6803-8130	300000～600000
For Cooling To wer Systems	TOWER CLEAN S-512	KURITA WATER INDUSTRIES LTD TEL 03-3347-3433	150～300

NOTE (1) ppm=mg/l

(2) Directions given by the manufacturer should be observed for methods of use and management.

(3) Brands without toxicity were selected out of those available on the market. It is permitted that other equivalent is used, but attention should be paid to toxicity.

3.3.3 Anti-freeze

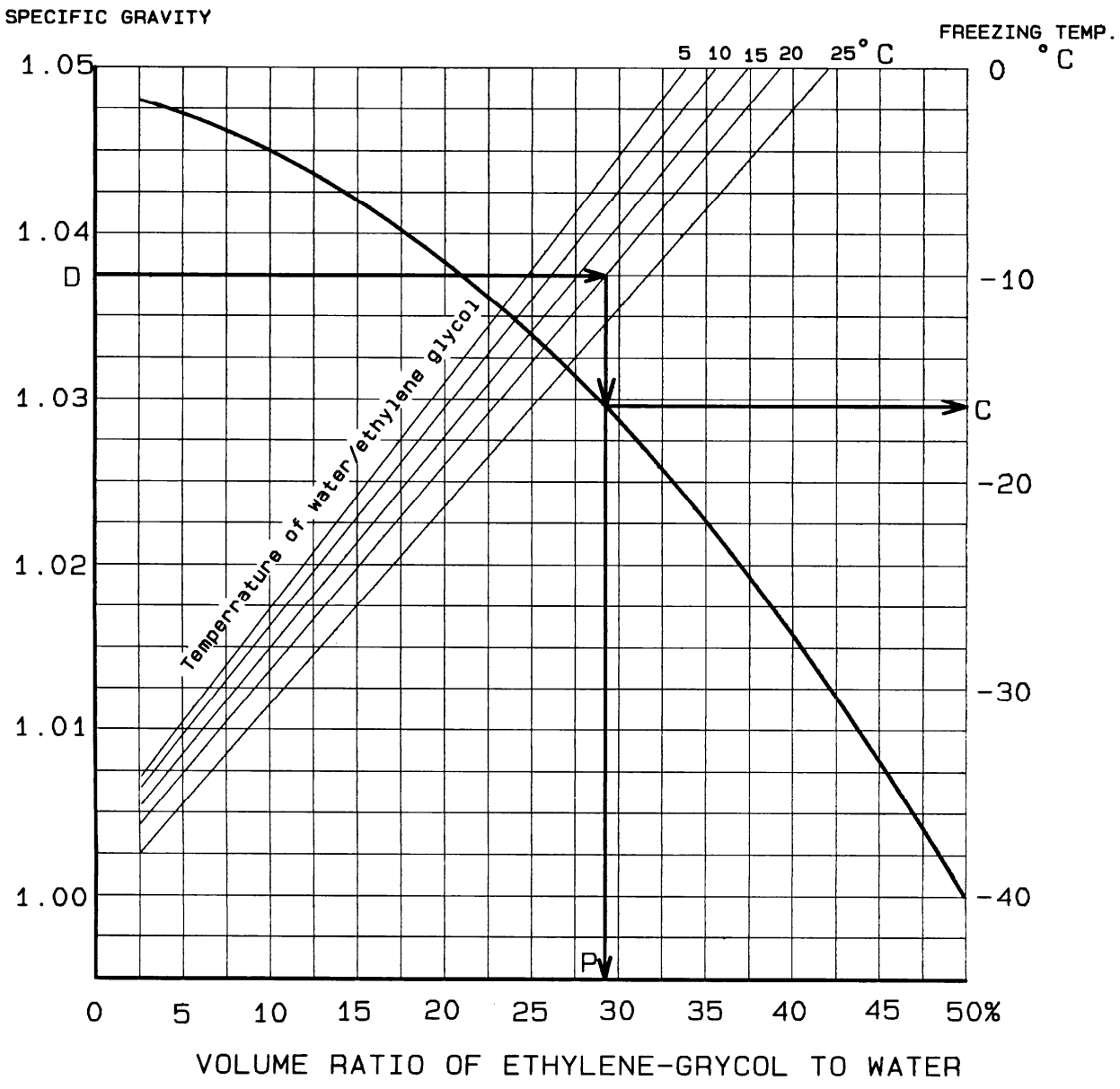
> ⚠ **WARNING :** Keep away form the fire since anti-freeze entails the danger of ignition to scald

Use anti-freeze using ethylene glycol as the base for the engine. Borate of nitrite type and benzoate of nitrite type may be used as the water treatment agent together with anti-freeze of this type, but water treatment agent of chromate type cannot be used together with anti-freeze of this type. The following figure indicates the following relations.

－Relation between ratio (P) and specific gravity (D) of anti-freeze.

It is for learning the concentration from the result of measurement using a hydrometer and the temperature at the time of measurement.

－Ratio (P) of anti-freeze and freezing temperature (C) of cooling water.



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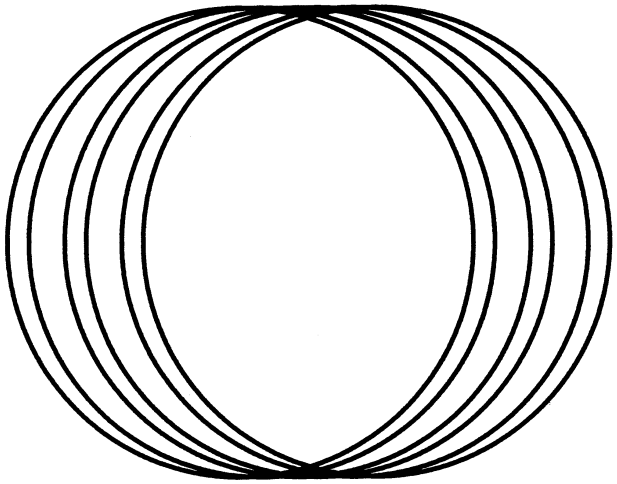

NIIGATA DIESEL
INSTRUCTION MANUAL
MG(L)28AHX

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4. ENGINE CONSTRUCTION

4.1 General construction

Model 28AHX comes in 6, 8, 9 inline-type, all of which have a cylinder bore of 280 mm and stroke of 390 mm. Most of the parts that are independent of the number of cylinders are common among them.

Normally, the gear train for camshaft drive and the governor drive gear are on the driving end, and the lubricating oil pump, cooling water pump, and its drive gear are on the free end.

The turbocharger and charge air cooler are located on the driving end.

(according to specification, these are located on the free end)

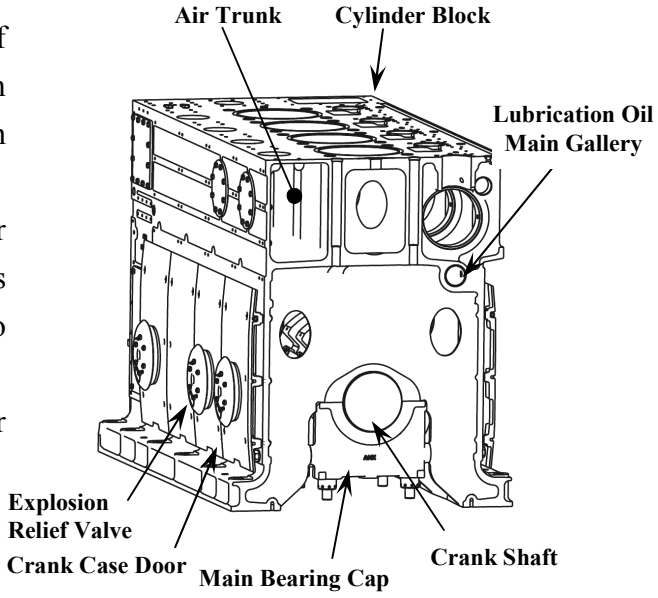
4.2 Cylinder block

The cylinder block has monoblock structure of nodular cast iron to acquire sufficient strength and rigidity to withstand the high-combustion pressure.

The crankshaft is installed using the hanger type, and the main bearing housing is tightened by stud bolts, nuts and side bolts to provide sufficient rigidity.

The cylinder block has big doors both sides for easy maintenance and inspection.

Also, one side crank case doors have explosion relief valves.



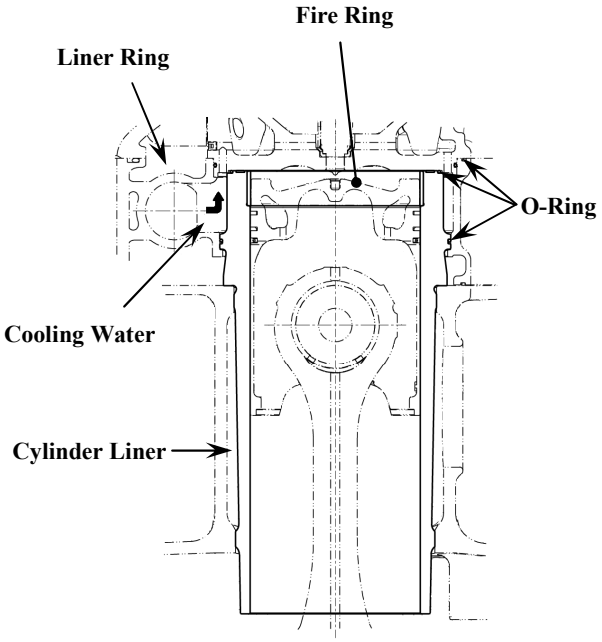
4.3 Cylinder liner

The cylinder liner is made of special wear resistant cast iron. The upper part of liner which is exposed to especially high temperature and pressure, has a rigid thick wall structure.

The jacket cooling system prevents thermal deformation. The liner ring has cooling water pipe that connected next cylinders.

The cooling water jacket is sealed with three O-rings at cylinder jacket.

A fire ring is inserted into the top of cylinder liner to prevent carbon polish and reduce lubricating oil consumption.

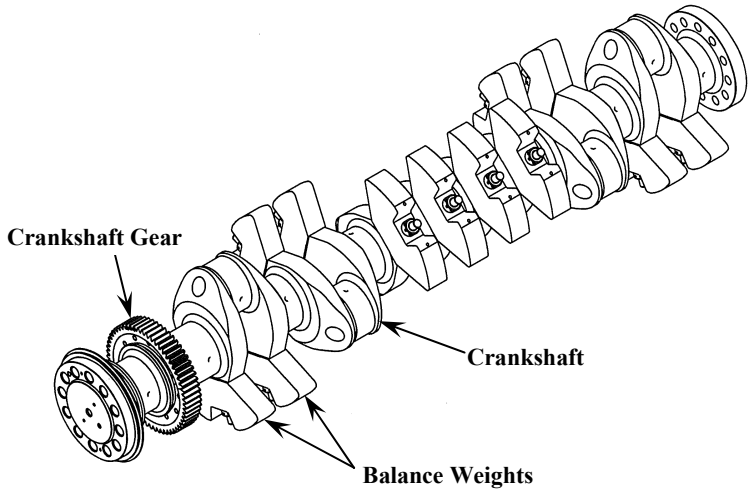


4.4 Crankshaft, Main Bearing and Location Bearing

(1) Crankshaft

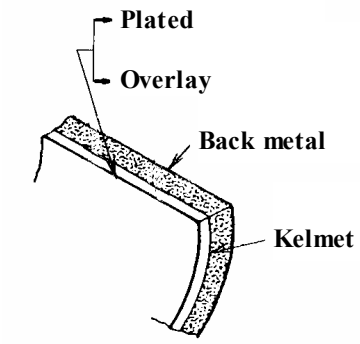
Crankshaft is made of high-strength special forged steel. Bearing can be used on the crank shaft. The crank shaft has two balance weights per throw to counteract the inertia of unbalanced weight generated by rotation, and to reduce the inertia force on the main bearings and reduce engine vibration.

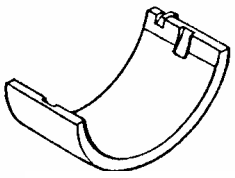
Crankshaft gear is installed to drive a camshaft by drive end side.



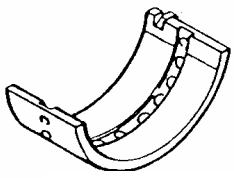
(2) Main Bearing

The main bearing is made of thin kelmet metal to provide resistance to pressure and strength. The kelmet metal is a multiple layer type composed of an iron back coated with kelmet (lead-bronze alloy), overlay with lead-tin alloy, and then plated flush with tin.





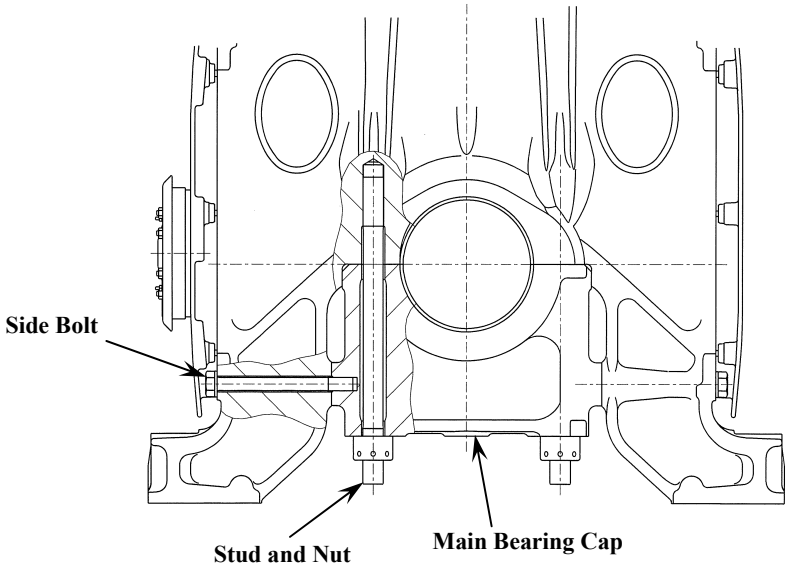
Lower bearing



Upper bearing

(3) Main Bearing Cap

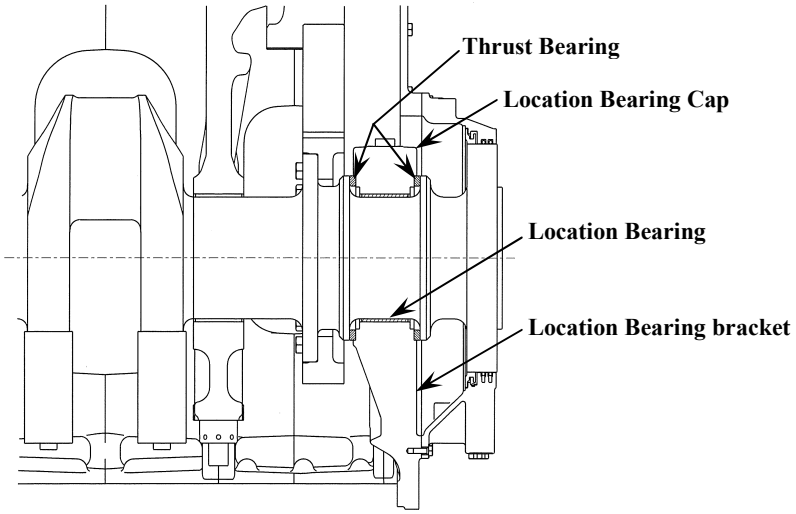
The main bearing caps are made of high-grade cast iron, and are designed large enough to increase the rigidity of the housing. The main bearing cap is fastened to the frame with two studs and two side bolts.



(4) Location Bearing

The outside bearing serves also as location bearing. The crankshaft is kept in position by the crankshaft thrust bearings on both sides of the location bearing cap. The thrust bearings consist of an iron back coated with metal, and are fixed to the upper half of the cap.

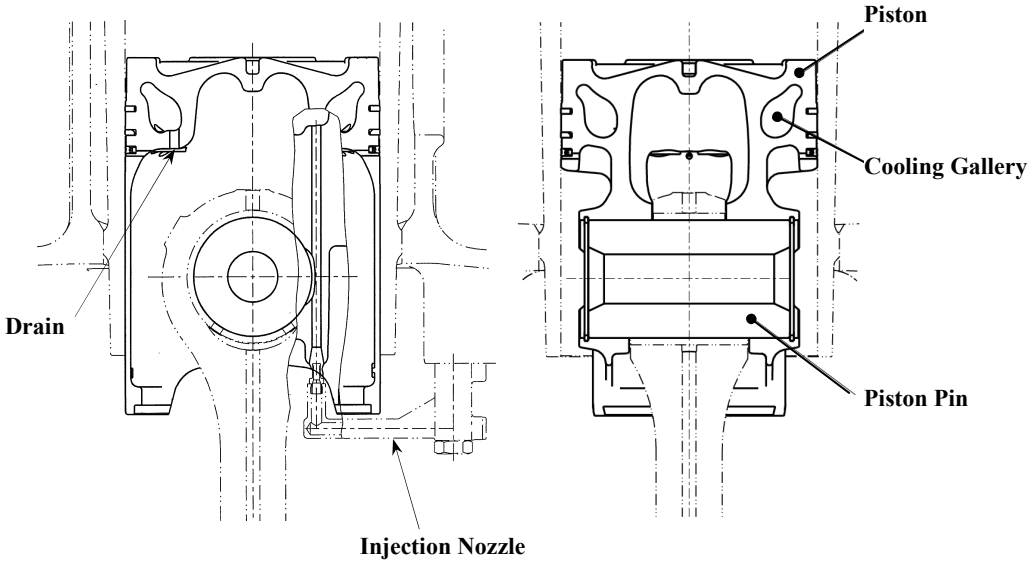
The outside bearing is the same as the main bearing.



4.5 Piston, Connecting Rod and Crank Pin Bearing

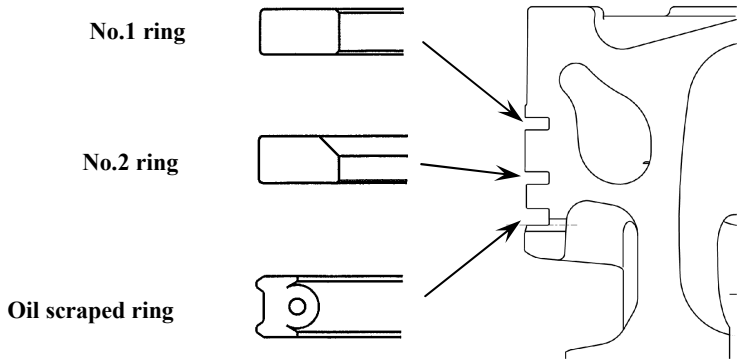
(1) Piston

The piston is monoblock type of nodular cast iron. The crown has a cooling gallery with sufficient volume and is cooled forcibly by a lubrication oil shaking system. Lubrication oil is injected by the injection nozzle located on the cylinder block. Lubrication oil through the cooling gallery in the piston, then discharge from drain hole. Piston cooling reduces the thermal deformation and stress of the piston head, and keeps the piston ring grooves at normal temperature, thereby preventing the rings from sticking



(2) Piston Ring

The piston rings are made of wear-resistant special cast iron. Those include two compression rings and one oil scrape ring. The No.1 ring(compression ring) is a specially coating ring. The one oil scraped ring is coil expander type.



(3) Piston Pin

Piston pin is made of hardened special steel. The piston pin is floating type. It bring good lubrication and excellent wear-resistant. The lubricating oil is flowing from the oil way in the crankshaft, crank pin bearing, connecting rod and piston pin bush.

(4) Connecting Rod

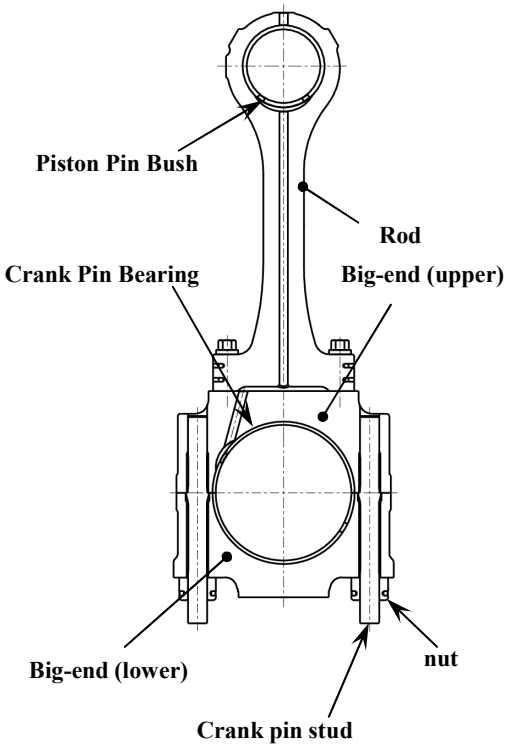
The connecting rod is made of special forged steel. The rod consists of three pieces, the rod(stem), the big-end cap(upper), and the big-end cap(lower).

Rod and big-end cap is tightened by 4 bolts, and cap is tightened by 2 stud bolts and nut.

When the piston is of pulled out in order to inspect the piston rings, the big-end does not need to be disassembled. Therefore height for disassembly of piston can be lowered.

As a result, allow for easy maintenance and inspection.

The small-end cap is equipped with a piston pin metal which back face is lined and overlaid the bearing alloy metal. The journal is connected to the piston via floating piston pin.



(5) Crank Pin Bearing

The crank pin bearing is made of thin kelmet metal of the same material and structure as the main bearing.

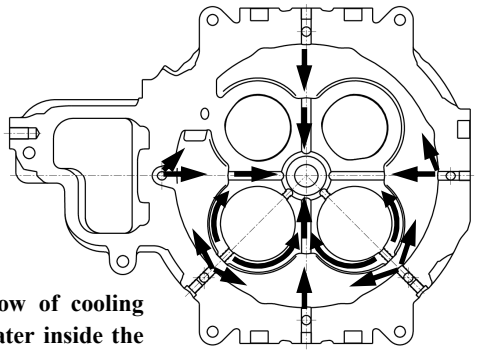
(6) Crank pin stud, nut

The crank pin stud is made of hardened special steel. The big-end cap and the crank pin bearing are tightened with two stud bolts by hydraulic jack.

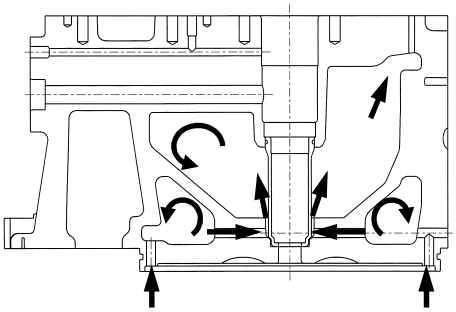
4.6 Cylinder Head

The cylinder head is made of CV(compacted vermicular) cast iron with high strength and thermal conductivity to withstand the thermal and mechanical stress caused by the increased combustion pressure.

Thermal stress is reduced through uniform cooling created by the optimized arrangement of the jacket cooling system. The highly rigid diagonal intermediate shelf structure and four bolts eliminate local stress concentration and gas leakage.



Flow of cooling water inside the cylinder head



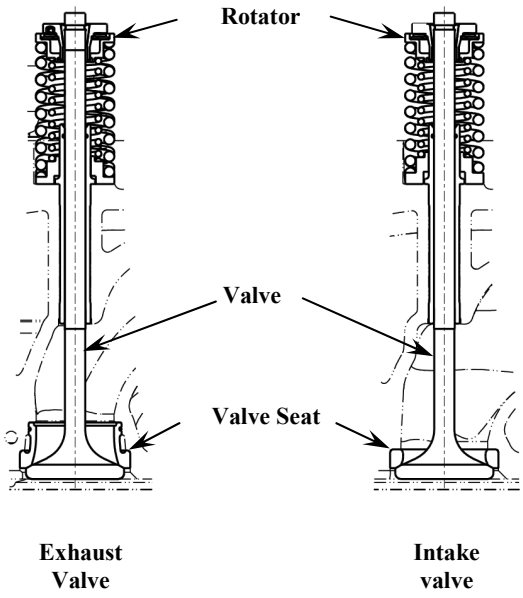
Cooling water from liner ring

4.7 Exhaust Valve, Intake valve

(1) Exhaust Valve

The exhaust valve is made of heat-resistant steel and a valve seat is installed into the cylinder head.

The exhaust valve seat receives cooling water from the cylinder head to cool itself enough, and then returns the water to the cylinder head. The exhaust valve has valve rotator, which extend maintenance intervals.

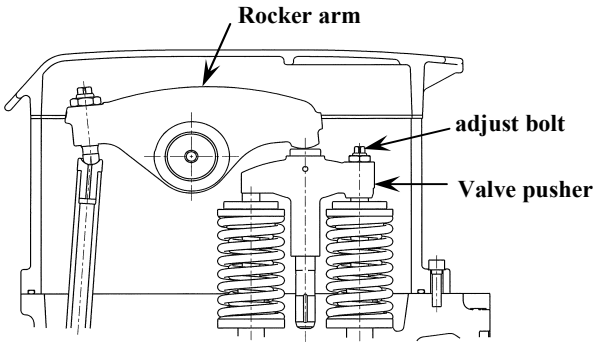


(2) Intake Valve

The intake valve consists of a valve spindle of heat-resistant steel and a valve seat of wear-resistant special steel. The intake valve seat is installed into the cylinder head. The intake valve has valve rotator, which extend maintenance intervals.

(3) Valve Rocker Gear

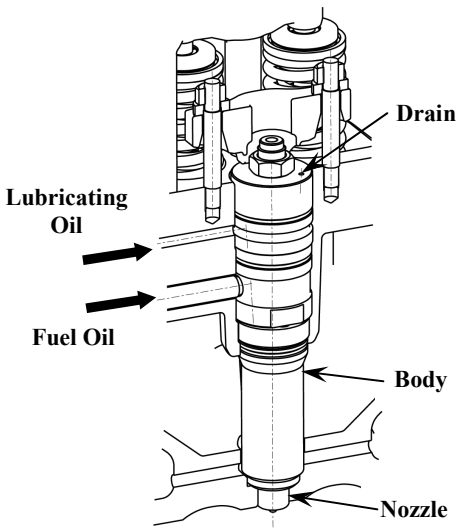
Each intake and exhaust valve is driven by one rocker arm via valve pusher. The valve pushers have an adjusting bolt. Adjusting bolt is installed due to match the valve timing during two intake valves or two exhaust valves.



4.8 Fuel Injector

The fuel injector consists of a forged steel body, a nozzle of heat-resistant, wear-resistant special steel, and an injection pressure regulating mechanism. The nozzle is a multiple-pore automatic valve. The diameter and number of pores and injection angle are so selected as to assure optimum combustion performance.

The injector nozzle is cooled by lubricating oil to prevent carbon flower formation on the tip of the nozzle.



4.9 Indicator Cock and Cylinder Safety Valve

(1) Indicator Cock

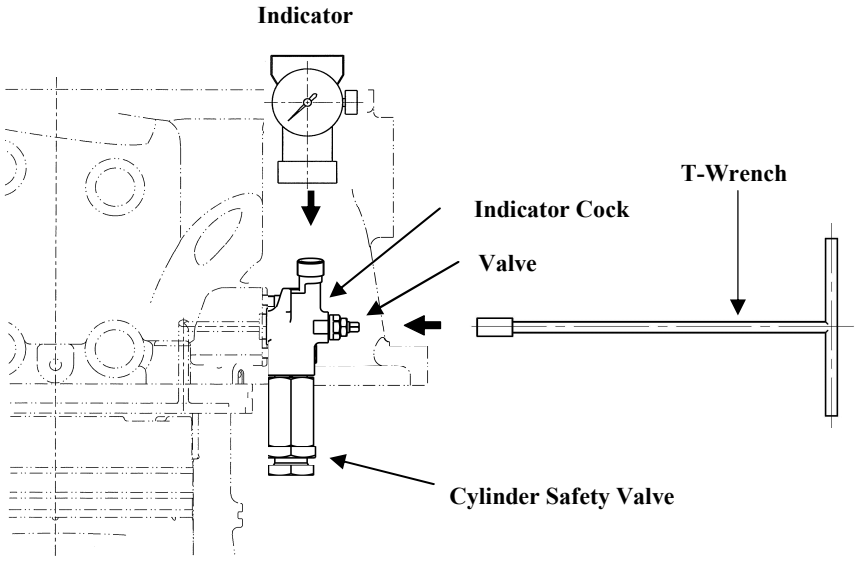
The indicator cock consists of a body of cast iron and a heat-resistant steel valve, and is opened and closed manually.

The indicator cock is used for decompression in turning or air running, and also for checking combustion in each cylinder with the cock opened during operation.

The indicator cock is also used for measuring maximum cylinder pressure with an indicator connected to the cock.

(2) Cylinder Safety Valve

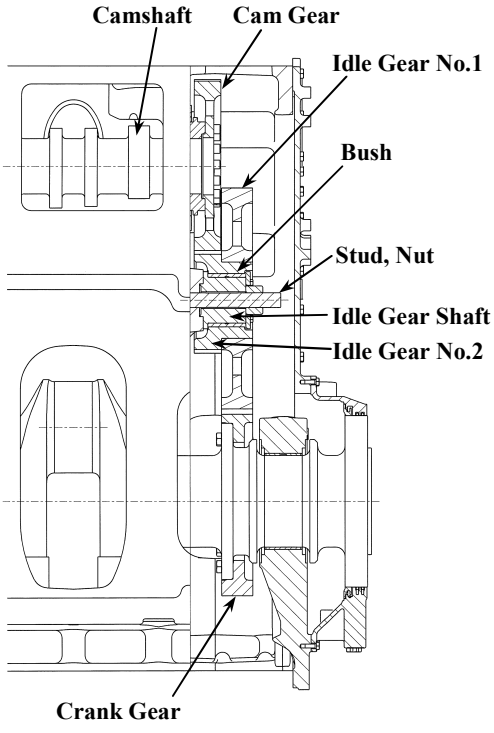
The cylinder safety valve is provided for protection from excessive cylinder pressure, and its opening pressure is selected to meet the applicable rules.



4.10 Gear Train for Camshaft

The camshaft gear drives the camshaft via idle gear from the crankshaft gear, which is fastened to the crankshaft. All gearwheels are made of special steel, and the tooth surfaces are hardened. The crankshaft gear is a half-split type, and is fastened to the crankshaft with reamer bolts.

The idle gear (double gear) is fitted over the hardened, forged steel shaft, which is fastened to the crankcase, and is turned via bronze bushings fixed into the gear.



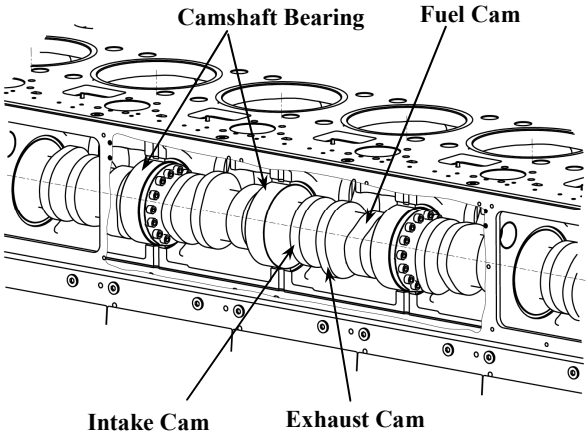
4.11 Camshaft and Camshaft Bearing

The camshaft is made of forged steel, and is driven by the camshaft gear fastened there.

A camshaft is divided two or three and is locked in position by some bolt.

The support of the camshaft is incorporated into the cylinder block. All cams actuate the fuel injection pumps and the intake and exhaust valves at the proper timing.

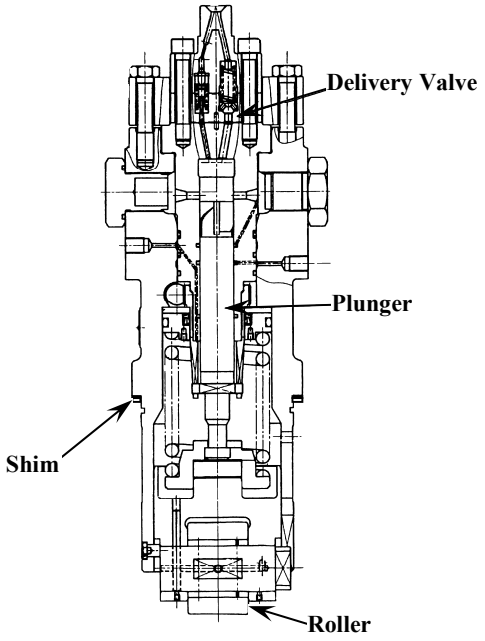
The camshaft bearing is made of steel-backed white-metal and is fitted in place by shrinkage.



4.12 Fuel Injection Pump

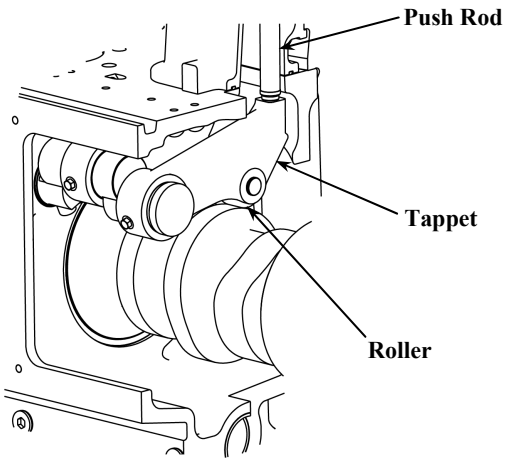
The fuel injection pump is a Bosch Type, the fuel injection pump and Roller guide became incorporate structure and their injection timing can be adjusted by shim thickness.

The delivery valve uses two-way delivery valve due to prevent cavitation erosion by change of pressure in injection pipe.



4.13 Cam Roller

The intake and exhaust push-rod are driven via roller and tappet by cam shaft.



4.14 VIVT(Variable Intake Valve Timing) mechanism

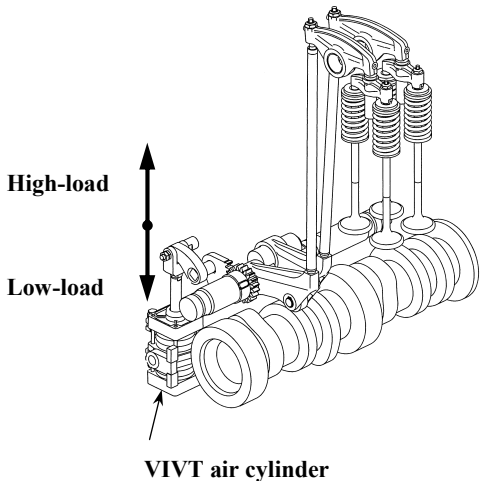
This engine has a VIVT(Variable Intake Valve Timing) system.

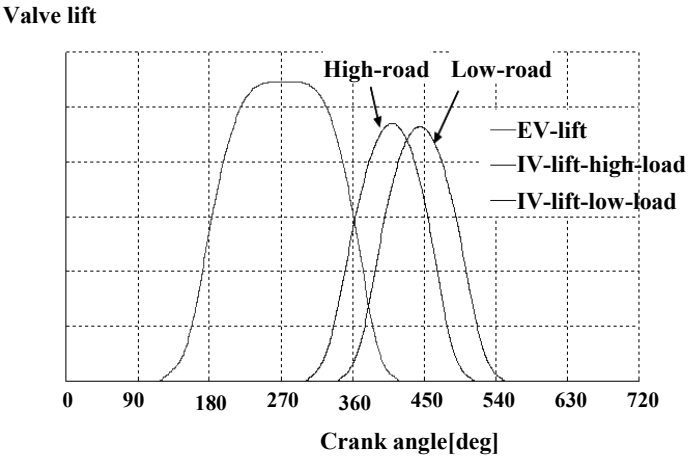
This mechanical VIVT system is used to achieve compatibility of high-load and low-load engine performance. The system shifts the intake valve timing, intake close timing and valve overlap are changed, simultaneously.

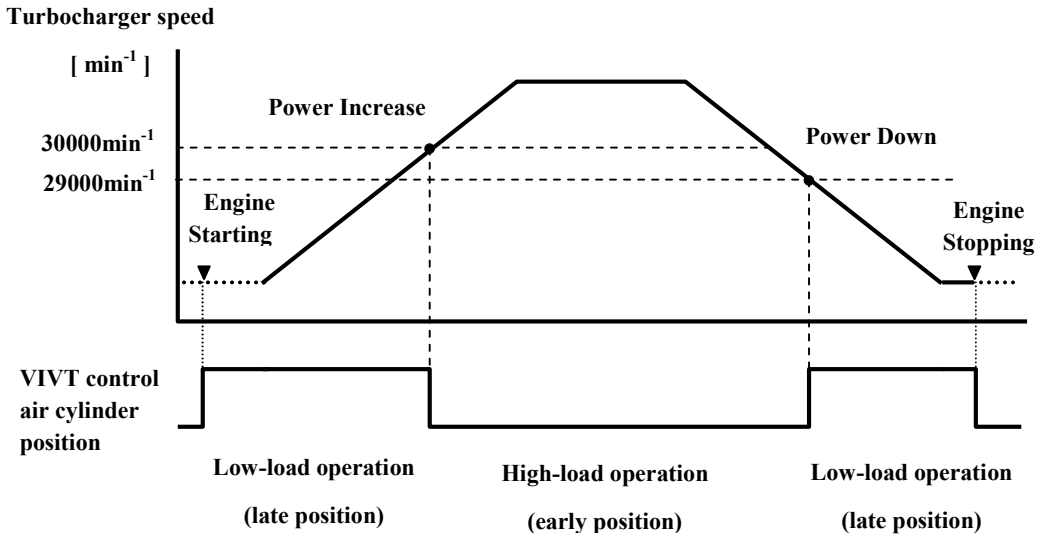
For low-load condition, this mechanism helps improvement of engine efficiency due to shortened valve overlap. On the other hand, the Miller cycle is achieved by advanced intake valve close timing and it leads lower NOx emission and good fuel consumption.

An air cylinder of VIVT is operated by control air. Operation of the VIVT system is controlled automatically the following base on the turbocharger speed.

- Low-load operation : Intake valve timing is late position
- High-load operation : Intake valve timing is early position







** These turbocharger speed are samples.
It depend on the engine output and specifications.

4.15 Air starter

The air starter is installed in driving end side, driven by compressed air.

Air run and engine starting can be controlled by remote control or switch of the Gauge board.

Operating theory of the air starter

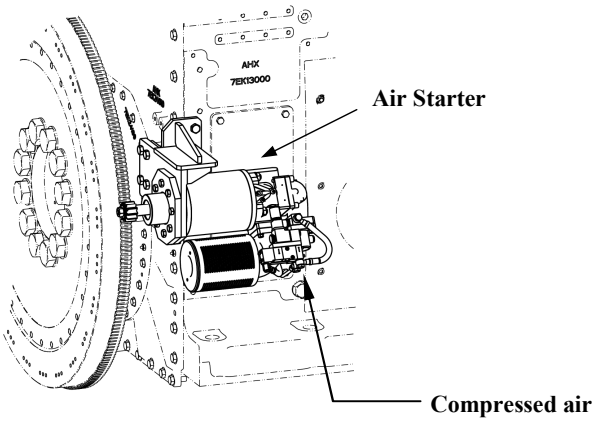
-First, the air starter drive pinion engages with the flywheel

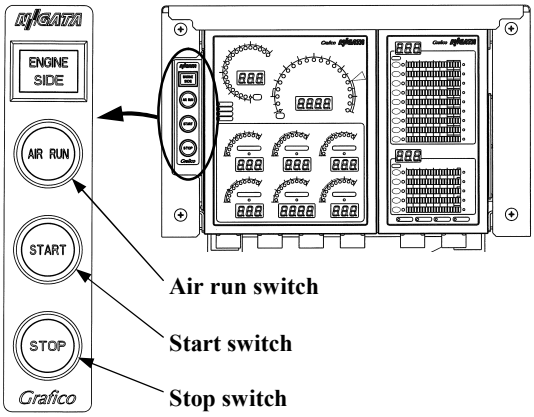
-Second, the main valve of the air starter opens

-Third, the engine is turned by the compressed air

If the drive pinion can not engage, or its working torque greater than starter one, drive pinion is automatically withdrawn to the idle position.

NOTE : For the construction and handling of the air starter , refer to the separate Instruction Manual for air starter.





4.16 Governor

The standard governor is a hydraulic type and controlled by microprocessor, which is accurate in operation and easy to maintain.

Speed command are given by the remote control or front control panel at the governor body.

NOTE : For the construction and handling of the hydraulic governor, refer to the separate Instruction Manual for Hydraulic Governor.

Maintain Governor every year. -Refer to paragraph **7.3**.

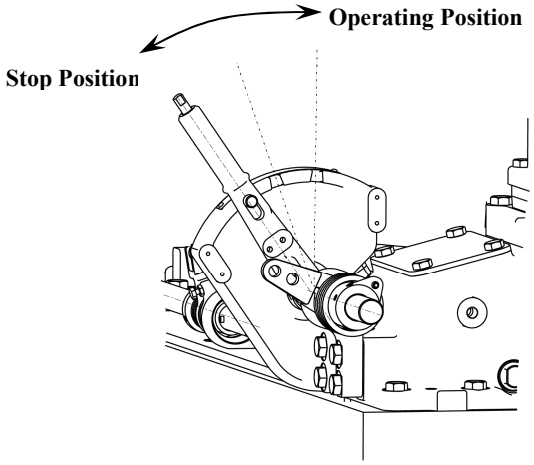
4.17 Maneuvering Device

The maneuvering device includes the fuel control lever, which is located on the driving end of the engine.

(1) Fuel Control Lever

The fuel control lever is connected to the fuel control lay shaft, and stops fuel injection at the "stop" position.

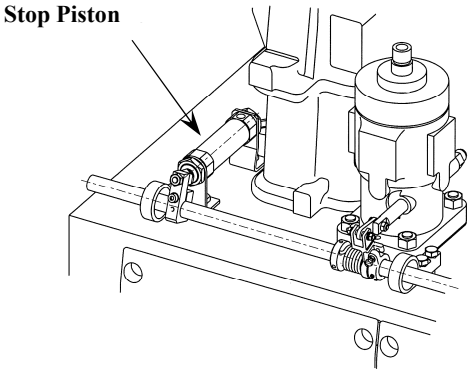
In "operating" position, the lever is disengaged from the fuel control lay shaft so that the fuel is controlled by the governor which interlocks with the fuel control lay shaft. Thus, operation by the governor takes place. The engine can be stopped and operated by means of the fuel control lever.



(2) Automatic stop valve

When automatically stopping the engine in the event of trouble, push the fuel control lay shaft toward STOP so that a fault signal will be emitted to the automatic stop device (air piston) via a solenoid valve.

The device is similarly used for remote control stop in general.



4.18 Front T/C Unit

Auxiliary equipments are integrated into a unit (Front T/C Unit), it is located at free end of the engine.

(1) Front T/C block

＜Equipment＞

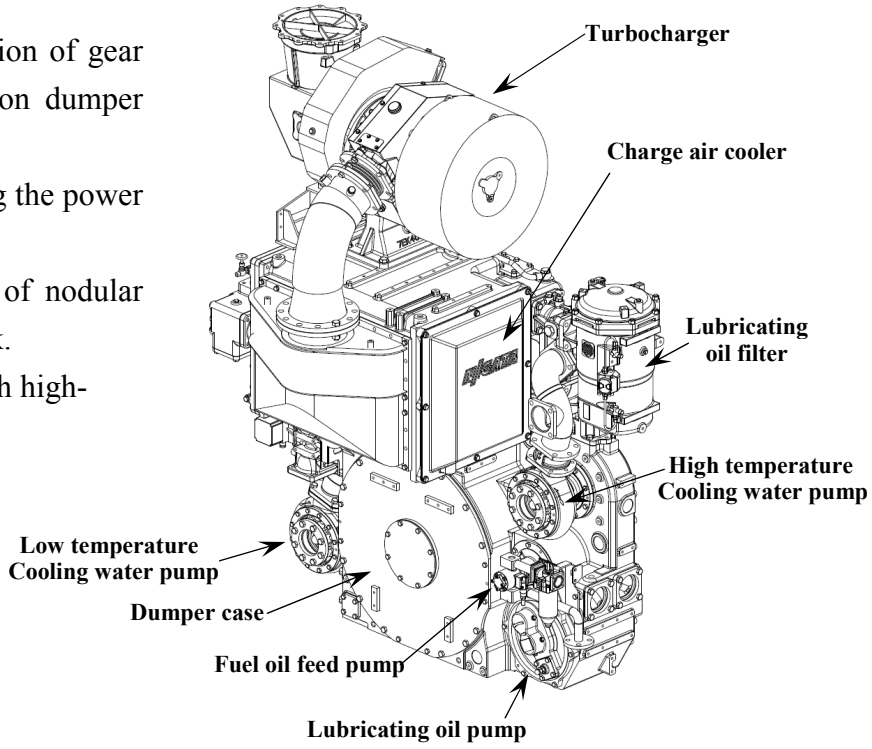
Lubricating oil systems	・・・・・	Lubricating oil pump, Filter
Cooling water systems	・・・・・	Cooling water pump
Fuel oil systems	・・・・・	Fuel oil feed pump, Filter
Turbocharger system	・・・・・	Turbocharger, Charge air cooler

The front T/C block has function of gear box case and torsional vibration dumper case.

Also, this case can be mounting the power take off shaft in free end side.

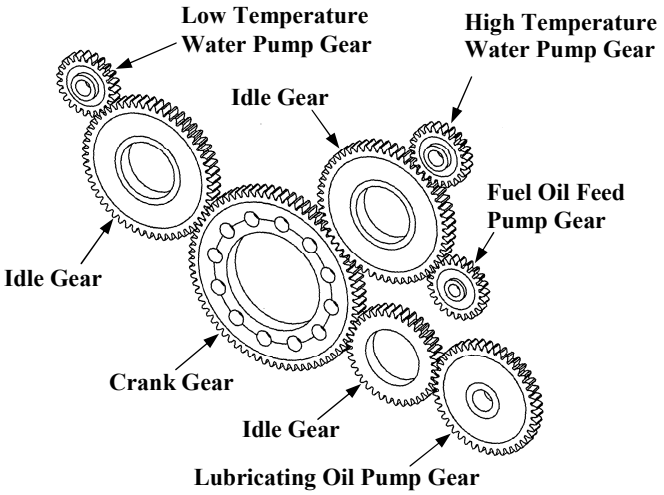
The front T/C block is made of nodular cast iron same as cylinder block.

It's fixed the cylinder block with high-tensile bolts and O-rings.



(2) Auxiliary pump driven gear train

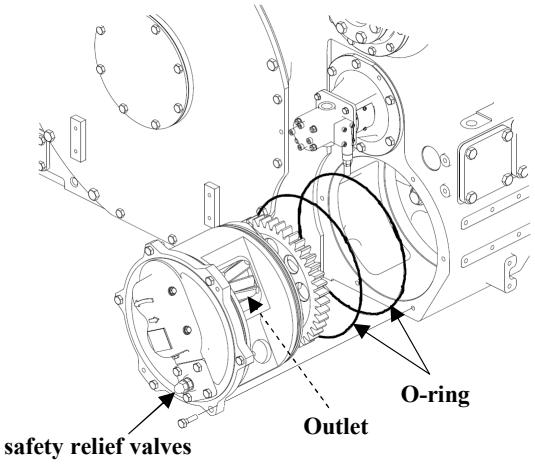
Lubricating oil pump, cooling water pump, fuel oil feed pump are driven by the crank gear on the crankshaft through the idle gear in the dumper case.



4.19 Lubricating Oil system

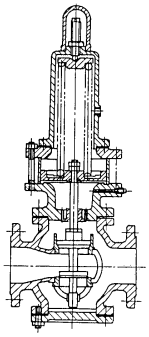
(1) Lubricating oil pump

The lubricating oil pump is a gear pump driven by the crankshaft gear via idle gear.
The lubricating oil pump is installed the front end unit with two O-rings.
It is equipped with built-on safety relief valve.
Depending on the specification, an independent motor-driven pump may be used.



(2) Regulating valve

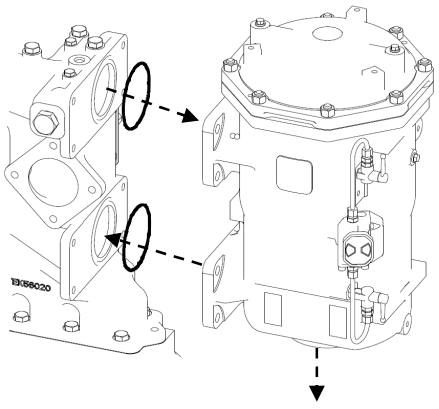
The lubricating oil regulating valve regulates lubricating oil pressure and also functions as a safety valve against excessive pressure rise.



Regulation valve

(3) Lubricating oil filter

The lubricating oil filter is the candle element type filter of automatic backflushing type, and it locates on the engine.
The filter elements are cleaned automatically, so that engine dose not have to be switched off for cleaning.
The differential pressure monitoring system measures the differential pressure between the filter inlet and filter outlet.
As the contamination increases, the differential pressure in the filter also increases.
The differential pressure monitoring system indicates the differential pressure optically provides electrical signal.



Backflushing oil outlet

NOTE : For the construction and handling the filter, refer to the separated Instruction Manual for the filter.

4.20 Cooling water system

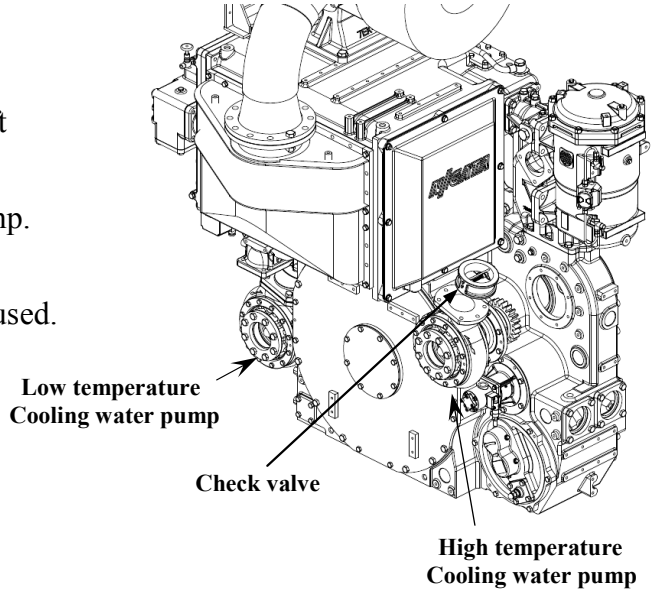
Cooling water system consist of two separate circuits or loops. High temperature fresh water feeds into the charge air cooler through the cylinder liner and cylinder head, the other low temperature fresh water (or sea water) feeds into the charge air cooler and lubricating oil cooler and fresh water cooler.

(1) Cooling Water Pump

It possible to equip two pumps for high temperature and low temperature (or sea water). These are driven by the crankshaft gear via idle gear.

There is the check valve for stand-by pump.

Depending on the specification, an independent motor-driven pump may be used.

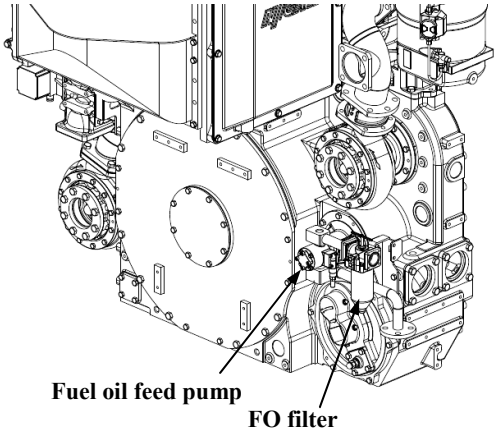


4.21 Fuel Oil Feed Pump

Fuel oil feed pump is a trochoid pump, which is driven by the crankshaft gear via idle gear.

Fuel oil discharged from the fuel feed pump passes the oil filter.

Depending on the specifications, an independent motor-driven pump may be used.

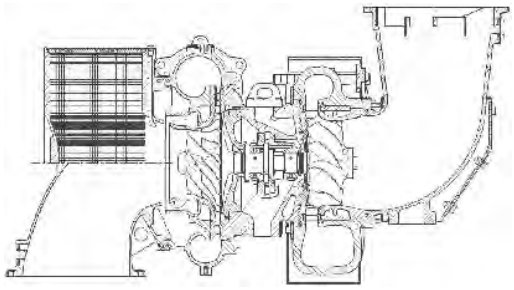


4.22 Turbocharger, Intake and Exhaust Manifolds

The turbocharger and charge air cooler are used for high engine performance and either of pulse charging system or constant pressure charging system is adopted depending on uses of the engine.

(1) Turbocharger

Type is ABB turbocharger and calculation and experiment select the best matching of turbine nozzle and diffuser to the engine.



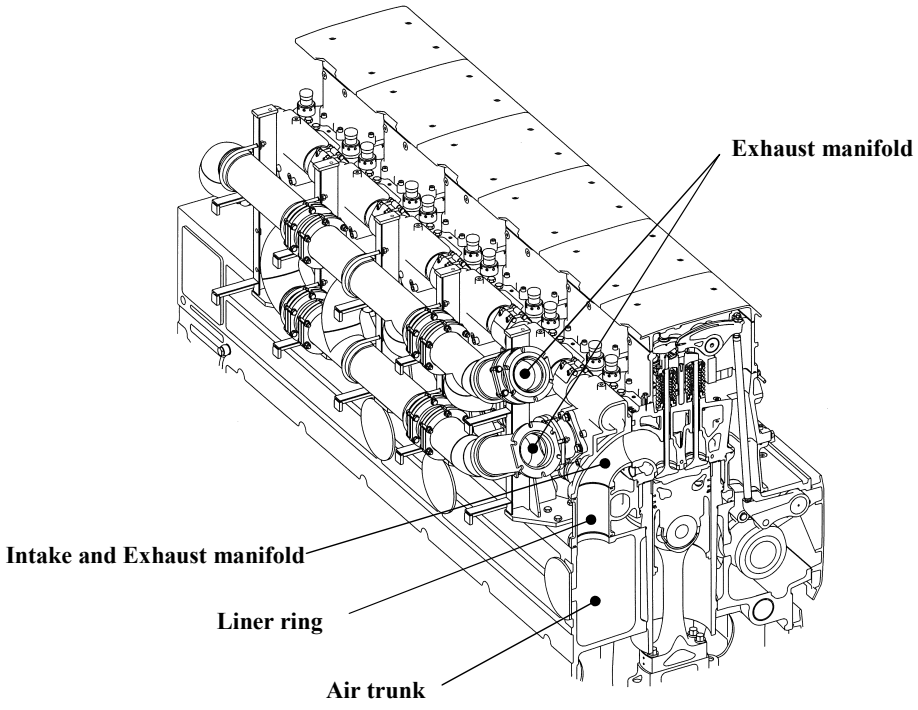
NOTE : For the construction and handling of the turbocharger, refer to the separated Instruction Manual for the turbocharger.

(2) Charge Air Cooler

The charge air cooler cools the air supplied from the turbocharger before it is fed into the cylinders. The air cooler is a 2-stage finned, multiple-tube type, whose capacity is selected as most suitable by calculation and experiment.

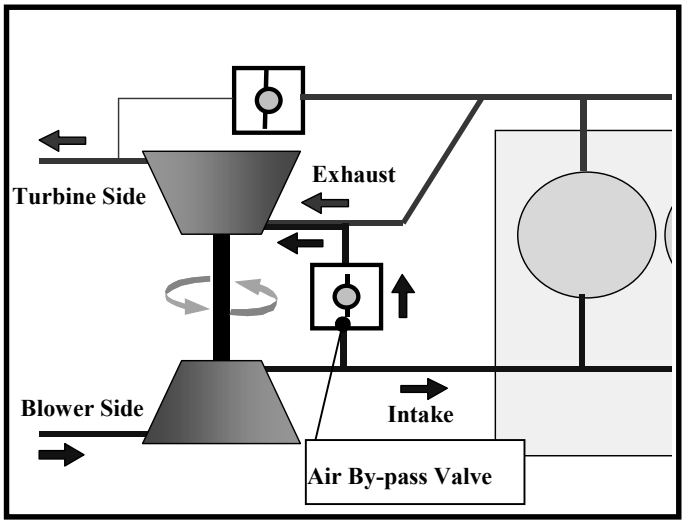
(3) Intake and Exhaust Manifolds

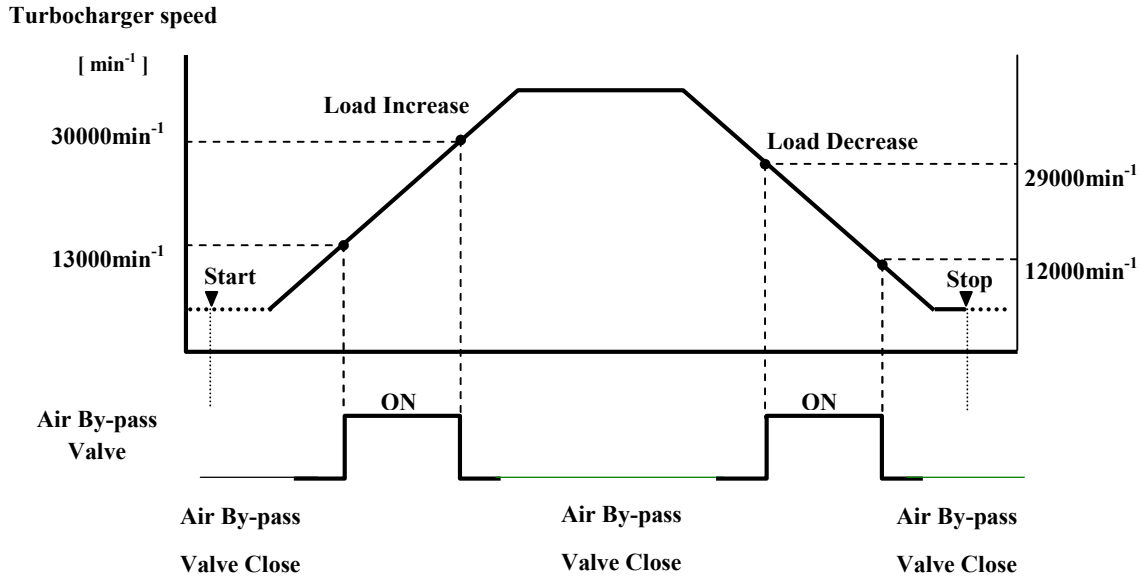
The air trunk is incorporated in the cylinder block and air inlet ducts integrated the liner ring and intake and exhaust manifolds connect the air trunk and the cylinder head.
It has flexible expansion joint to cope with thermal expansion.



(4) Air bypass system

The turbo charging system includes air bypass system. This system by-pass a part of compressed air to the blower of turbocharger at low and medium-load operation.
As a result, the turbocharger speed increase and charge air pressure and flow volumes increase.
Air bypass system improves combustion efficiency and reduce smoke emissions.
The air bypass system is operated by control air to the air bypass valve, and operation is controlled automatically base on the turbocharger speed as follow.



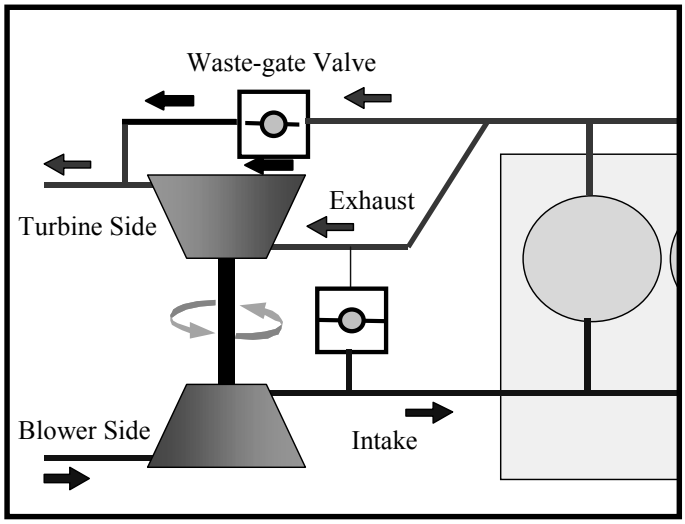


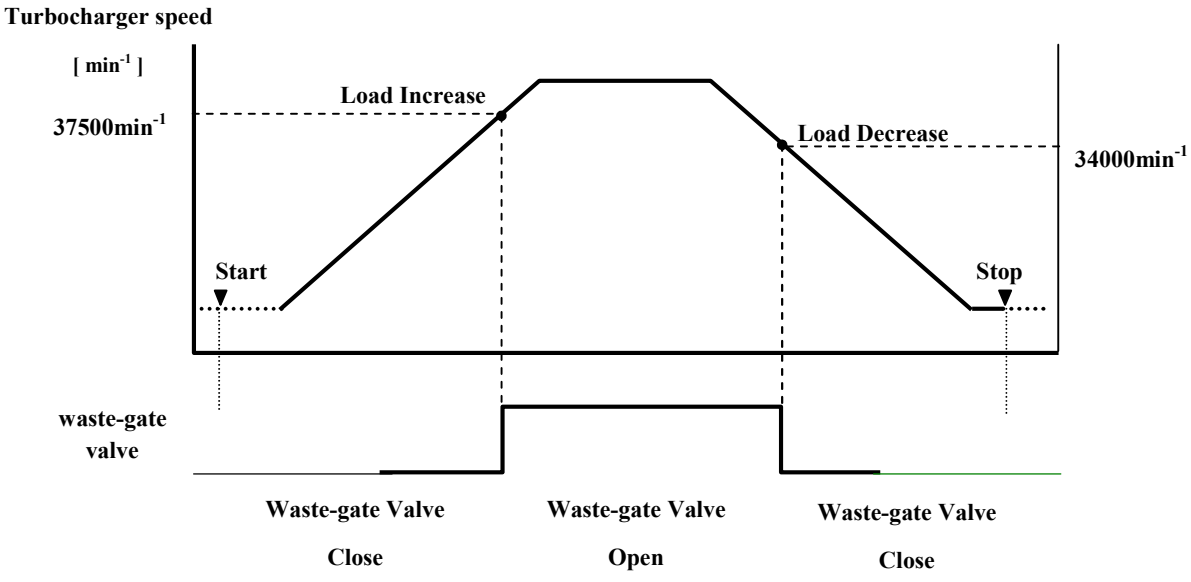
** These turbocharger speed are samples.
It depend on the engine output and specifications.

(5) Waste-gate system（Depend on specification）

The turbo charging system includes waste-gate system. This system controls the turbocharger speed and prevents the combustion pressure in the cylinder within the designed value at over-Load operation.

The waste-gate system is operated by control air to the waste-gate valve, and operation is controlled automatically base on the turbocharger speed as follow.

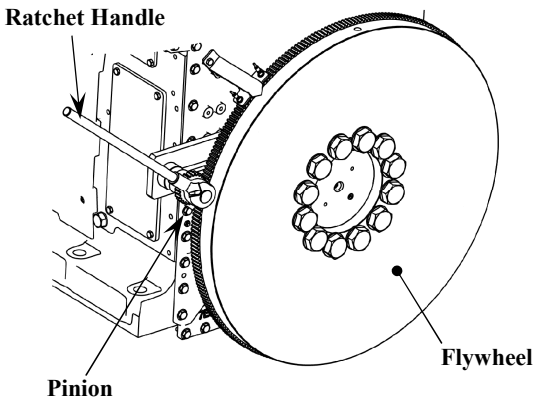




** These turbocharger speed are samples.
It depend on the engine output and specifications.

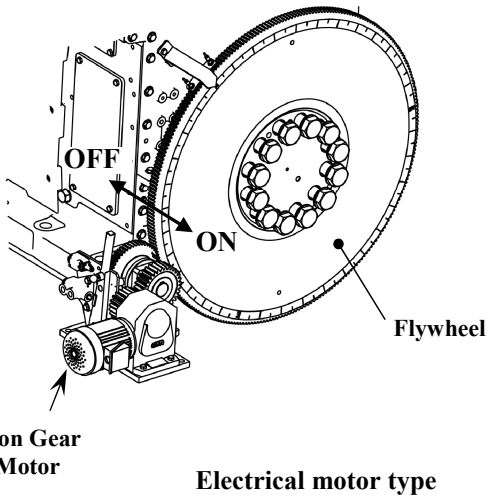
4.23 Turning Device

The normal turning device is a ratchet handle type. It turns the engine rotating the flywheel by ratchet handle and pinion. The optional turning device is a electrical motor type with a reduction gear. It can turn the engine to rotate the flywheel by electrical motor.



Ratchet handle type

(Normal)



Electrical motor type

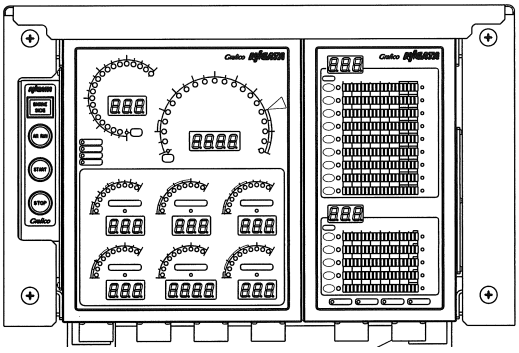
(Optional)

4.24 Gauge Board

This engine is use a electrical gauge board with digitally and bar graphs using LED for excellent visibility and rapid assessment of engine status, contributing to engine safety operations.

Display items

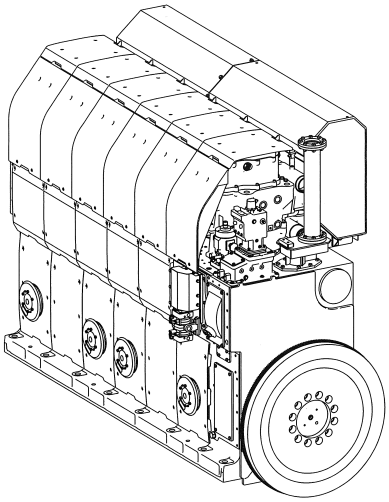
- Engine speed
- Turbocharger speed
- Lubricating oil pressure
- Cooling water pressure
- Fuel oil pressure
- Charge air pressure
- Exhaust temperature

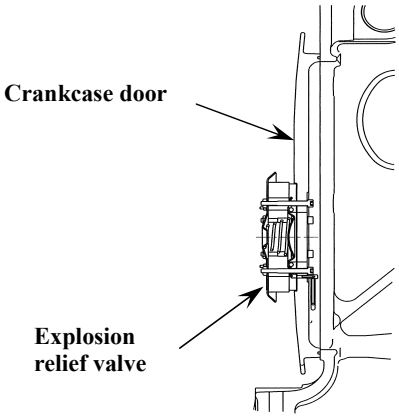


4.25 Crankcase Explosion relief Valve

Explosion relief valves are installed on the crankcase doors to prevent accidents due to abnormal pressure inside the cylinder block.

Explosion relief valve capacity and opening pressure are selected according to the applicable rules.

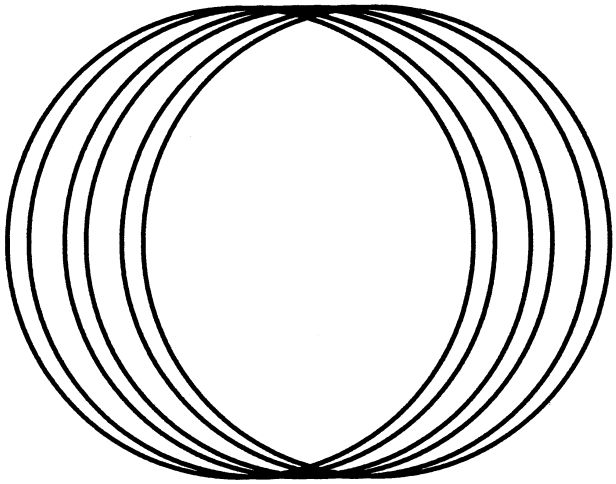




⚠ DANGER

Where the engine is brought to a stop due to abnormal heat generation being detected inside the engine room, there is a danger of explosion if crankcase door is allowed to open forthwith. Open the door after the lapse of a cooling period of not less than 20 minutes.

MEMO



NIIGATA DIESEL INSTRUCTION MANUAL

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5 ADJUSTMENT STANDARDS
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5.2 Tightening Specification
of Main Parts ---------- 5-13
5.3 Temperature settings ---------- 5-19
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5. ADJUSTMENT STANDARDS FOR MAIN PARTS

Adjust the main parts as indicated in the table after page 5-2. If the specified limits are exceeded, readjust, repair or replace the parts.

Standard ---------- Manufacturing standards for new engine.

Permissible limit ---- Parts exceeding the permissible limit must be repaired or replaced at periodic inspection and maintenance time.
(Maintenance control standard)

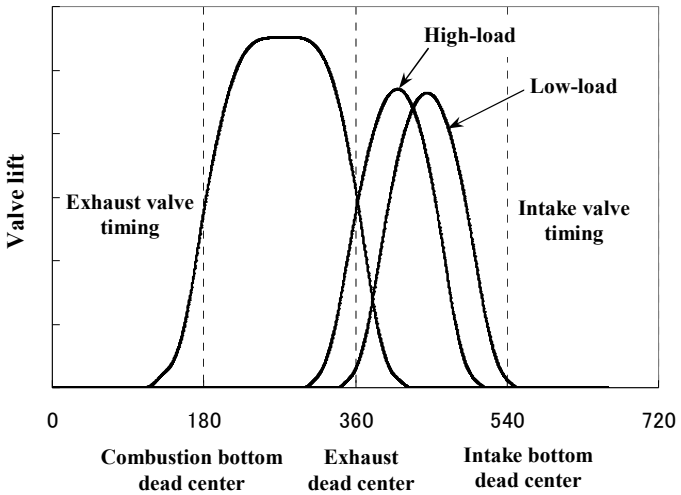
NOTES

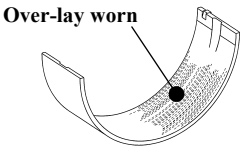
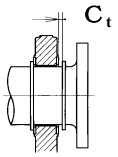
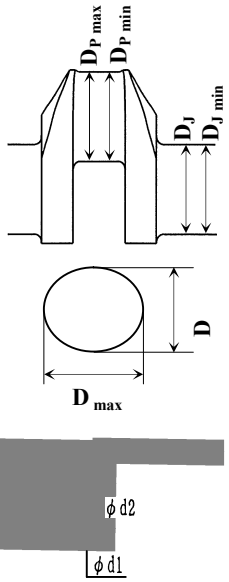
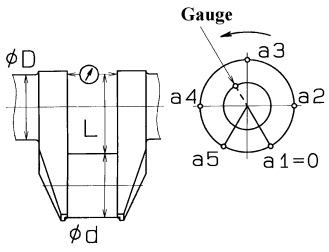
(1) Standard clearance shows dimensional difference of new engines.

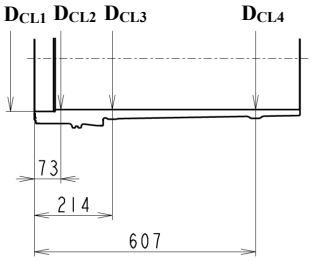
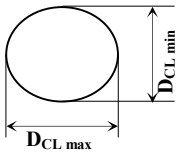
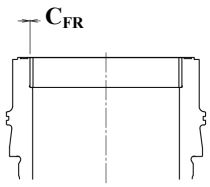
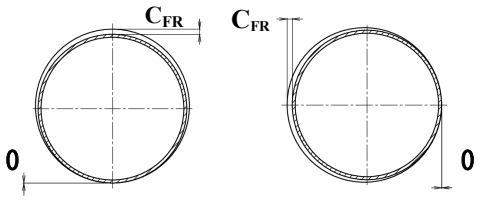
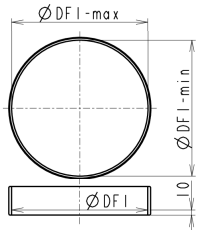
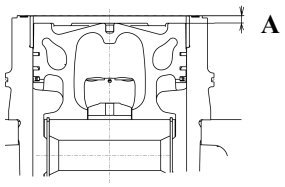
(2) When measuring clearance with feeler gauges, add 0.01 to 0.02 mm to the measured values for the correct clearance.

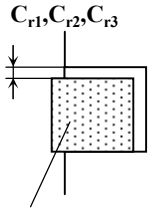
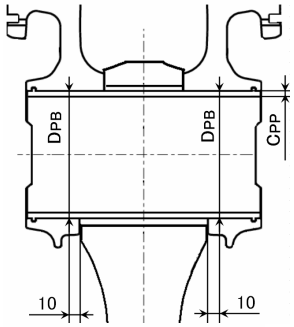
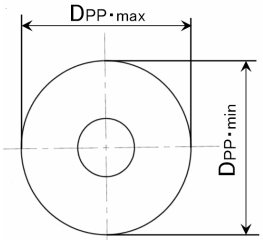
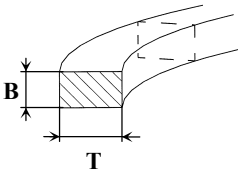
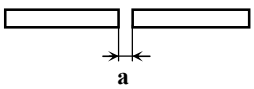
5.1 Parts Adjustment Standards

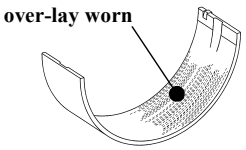
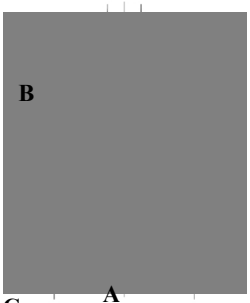
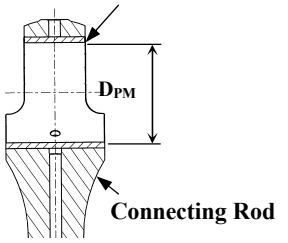
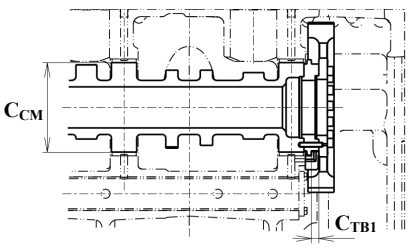
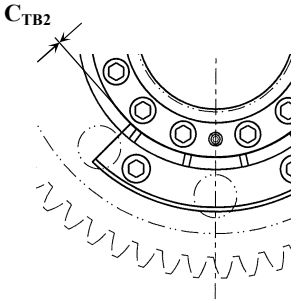
No.	Adjusting point			Nominal size (mm)	Clearance, Wear Limit		Description
					Standard (mm)	Permissible Limit (mm)	
1	Fuel Injection Nozzle Valve opening pressure				50MPa		Adjust with injection test pump
2	Fuel injection pump rack scale • Rack scale at engine stop • Scale difference during operation (at maximum continuous output)					0± 1 or less 3 or less	If serious difference is found, engine may not come to a stop even if fuel control lever is moved to STOP position.
3	Maximum cylinder pressure				18MPa below	Deviation less than 0.5MPa	Adjust at maximum continuous output (See test record)
4	Intake valve timing	Low-road	Opening start	—	13°	—	Before exhaust top dead center
			Closing end	—	6°	—	After intake bottom dead center
		High-road	Opening start	—	53°	—	Before exhaust top dead center
			Closing end	—	34°	—	Before intake bottom dead center
5	Exhaust valve timing		Opening start	—	59°	—	Before combustion top dead center
			Closing end	—	53°	—	After exhaust top dead center

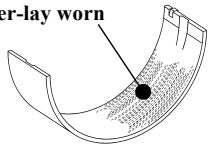
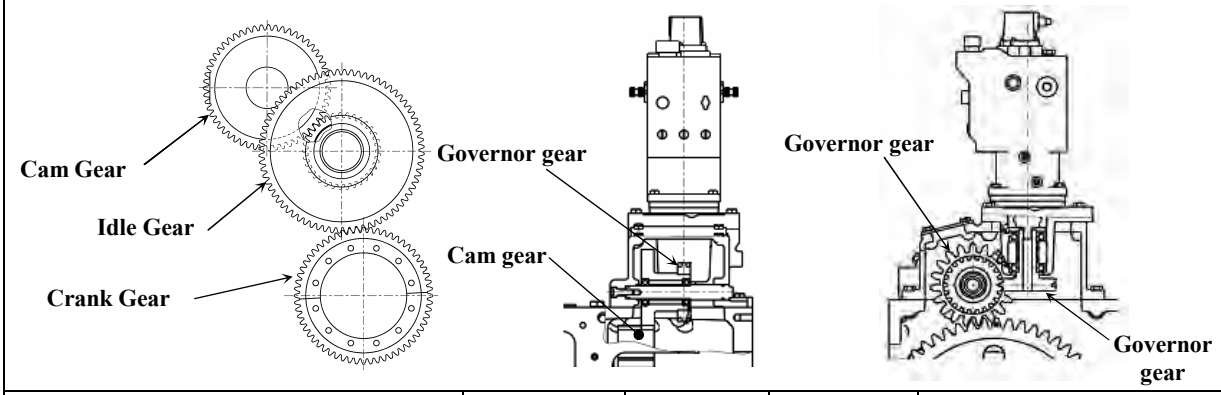
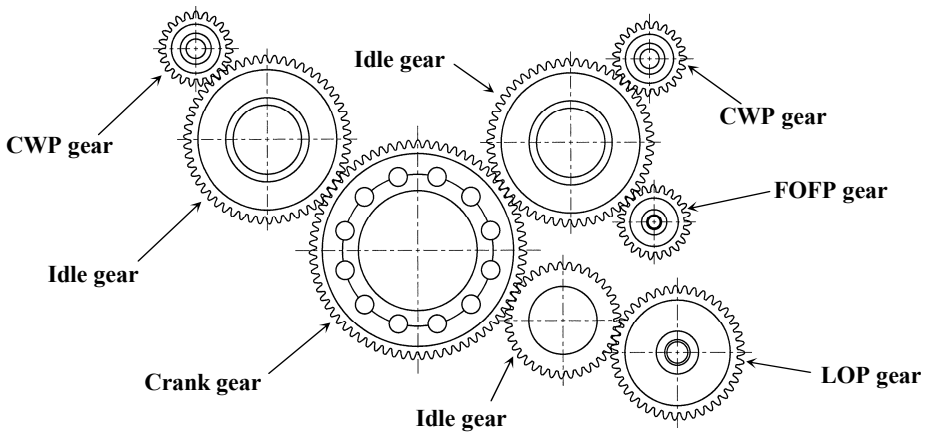


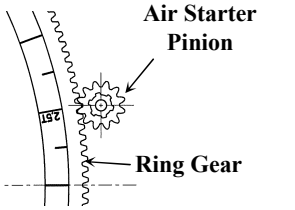
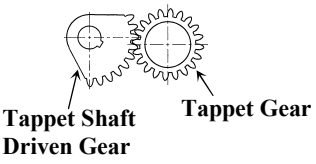
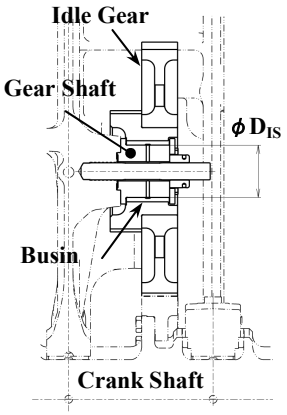
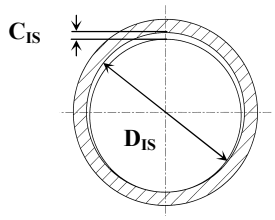
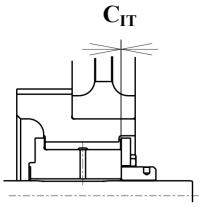
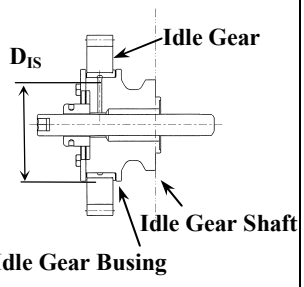
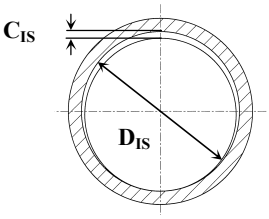
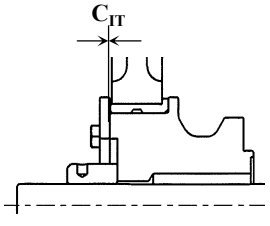
No.	Adjusting point	Nominal size (mm)	Clearance, Wear Limit		Description
			Standard (mm)	Permissible Limit (mm)	
6	Main Bearing • Clearance between main bearing and journal C_J	Journal dia. ϕ 240	0.24~0.331	Note	
	Note • Measure with feeler gauges when bearing is cold. • If overlay wear is more than 30%, replace bearing.				
7	Thrust bearing clearance C_t		0.50~0.602	0.75	
	Note • Adjust by oversize thrust metal or shim.				
8	Crankshaft •Crank pin diameter D_P	Crank pin dia. ϕ 240	0 240 -0.029	239.86	
	•Journal diameter D_J	Journal dia. ϕ 240	0 240 -0.029	239.86	
	• dimension				
	Crank pin $D_{P\,max} - D_{P\,min}$		—	0.04	
	Journal $D_{J\,max} - D_{J\,min}$		—	0.04	
	• Shaft uneven wear $D_{max} - D_{min}$		—	0.10	
	• Shaft cam wear ϕ d2- ϕ d1		—	0.01	
	Note • If wear exceeds limit, grind crankshaft and use undersized bearing.				
9	Crankshaft deflection 		≤0.04 (1/10000×S)	≤0.08 (2/10000×S)	Value at left applies where L=195 when engine cold. If size L differs, repair as per formula at left.
			Deflection= $\frac{S/2+D/2}{d/2+L}$ × Actual measurement ・S : Stroke 390mm ・D : Journal diameter 240mm ・d : Crank pin diameter 240mm		
	Note • A1 should be 0 where gauge will Inter fare with connecting rod and piston close to bottom dead center. • Different between maximum and minimum value of a2, a3 ,a4 or a 5 represents crankshaft deflection.				

No.	Adjusting point	Nominal size (mm)	Clearance, Wear Limit		Description
			Standard (mm)	Permissible Limit (mm)	
10	Cylinder liner • Inner diameter				
	D_{CL1}	ϕ 290	$^{+0.052}_{0}$ 290		
	D_{CL2}	ϕ 280	$^{+0.052}_{0}$ 280	280.35	
	D_{CL3}	ϕ 280	$^{+0.052}_{0}$ 280	280.35	
	D_{CL4}	ϕ 280	$^{+0.052}_{0}$ 280	280.35	
	• Uneven wear $D_{CL\,max} - D_{CL\,min}$		0.02	0.4	
11	Fire ring • Clearance between liner and fire ring C_{FR}	ϕ 290	0.056 ～0.160	0.2	
	Note • Measures clearance between liner and fire ring , when fire ring get together other side.				
	• Fire ring uneven wear $D_{FR\,max} - D_{FR\,min}$	Inner dia. ϕ 278.3	—	0.2	
12	Piston • Top clearance **A**	14	—	—	**Top clearance** 
	Note • At the top dead center, measure the dimension A to remove the cylinder head, because measurement of the top clearance is impossible.				

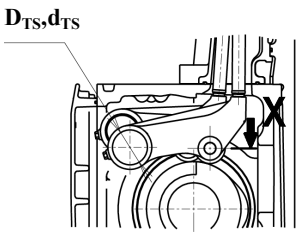
No.	Adjusting point	Nominal size (mm)	Clearance, Wear Limit		Description
			Standard (mm)	Permissible Limit (mm)	
	Piston • Clearance between ring groove and piston ring				 Piston ring
	Top ring C_{r1}		0.21~0.25	0.35	
	2nd ring C_{r2}		0.11~0.15	0.25	
	Oil ring C_{r3}		0.043~0.078	0.25	
	Note • Measure with feeler gauge when engine cold.				
	• Piston pin boss diameter D_{PB}	ϕ 130	$130^{+0.06}_{+0.04}$	130.10	
	• Clearance between piston boss and piston pin C_{PP}		0.06～0.10	0.15	
	• Piston pin uneven wear $D_{PP\ max} - D_{PB\ min}$		≦0.01	≦0.03	
13	Piston ring				
	• Ring width B				
	Top ring	6	$6^{-0.01}_{-0.03}$	—	
	2nd ring	6	$6^{-0.01}_{-0.03}$	—	
	Oil ring	8	$8^{-0.013}_{-0.028}$	—	
	• Ring thickness T				
	Top ring	10.4	10.4±0.15	—	
	2nd ring	10.4	10.4±0.15	—	
	Oil ring	5.5	5.5±0.15	—	
	• Ring gap a				
	Top ring		1.1~1.4	—	
	2nd ring		1.1~1.4	—	
	Oil ring		0.90~1.30	—	

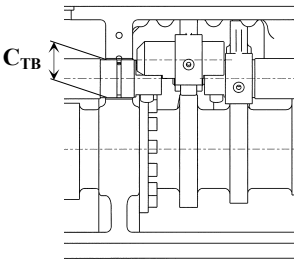
No.	Adjusting point	Nominal size (mm)	Clearance, Wear Limit		Description
			Standard (mm)	Permissible Limit (mm)	
14	Crank pin bearing • Clearance between crank pin bearing and crankshaft C_p	Pin dia. ϕ 240	0.18~0.271	Note	
	Note • Measure with feeler gauges when bearing is cold. • If overlay wear is more than 30%, replace bearing.				
15	Connecting rod • Connecting rod uneven diameter **OV** **OV=A-(B+C)/2**	Big end inner dia. ϕ 252		0.1	
	• Piston pin bush inner diameter D_{PM}	ϕ 130	+0.155 130 +0.10	130.21	
	• Clearance between piston pin bush and piston pin C_{PM}		0.12～0.195	0.30	
	Note • Measure inner diameter of big end side housing after tightening stud nuts and bolts. • Refer to Chapter 7.5.2 (k), to see tightning order .				
16	Cam shaft • Clearance between cam shaft and cam shaft bearing C_{CM}		0.15～0.278	0.4	
	• Clearance between cam shaft and thrust bearing C_{TB1}		0.2～0.4	0.7	
	• Clearance between cam shaft bearing and plate C_{TB2}		0.35～0.45	—	

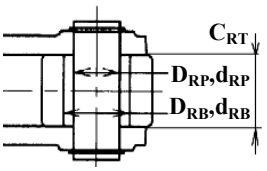
No.	Adjusting point	Nominal size (mm)	Clearance, Wear Limit		Description
			Standard (mm)	Permissible Limit (mm)	
17	Power take off shaft bearing (option) • Clearance between bearing and power take off by free end side. C_{PT}	Journal dia. ϕ 185	0.14~0.238	Note	
	Note • Measure with feeler gauges when bearing is cold. • If overlay wear is more than 30%, replace bearing.				
18	Gear train backlash				
	＜Driving end side＞	Module	Backlash		
	• Crank gear～Idle gear	m=8	0.24～0.40	0.6	
	• Idle gear～Cam gear	m=8	0.24～0.40	0.6	
	• Cam gear～Governor gear	m=8	0.24～0.40	0.6	
	• Governor gear～Governor gear	m=3.5	0.17～0.45	0.6	
					
	＜Free end side＞	Module	Backlash		
	• Crank gear～Idle gear	m=7	0.21~0.35	0.5	
	• Idle gear～LOP gear	m=7	0.21~0.35	0.5	
	• Idle gear～CWP gear	m=7	0.21~0.35	0.5	
	• Idle gear～FOFP gear	m=7	0.21~0.35	0.5	
					

No.	Adjusting point	Nominal size (mm)	Clearance, Wear Limit		Description
			Standard (mm)	Permissible Limit (mm)	
	• Ring gear～Air starter pinion	Module m=5	Backlash 0.4~0.7	Backlash 0.8	
	• Tappet Shaft driving gear		0.15~0.25		
19	Idle gear and gear shaft of transmission gear train ＜Driving end side＞ • Busing inside diameter D_{IS}	ϕ 120	+0.032 120 -0.078		
	• Clearance between busing and idle gear shaft C_{IS}		0.05～0.18	0.28	
	• Thrust clearance C_{IT}		0.20～0.60	0.70	
	＜Free end side＞ • Busing inside diameter D_{IS}	ϕ 145	+0.045 145 0	—	
	• Clearance between busing and idle gear shaft C_{IS}		0.10～0.17	0.27	
	• Thrust clearance C_{IT}		0.20～0.40	0.50	

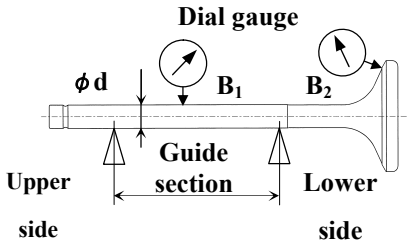
No.	Adjusting point	Nominal size (mm)	Clearance, Wear Limit		Description
			Standard (mm)	Permissible Limit (mm)	
20	Valve gear				
	• Tappet inner diameter **D_{TS}**	ϕ 70	+0.025 70 +0.011	—	
	• Shaft diameter **d_{TS}**	ϕ 70	-0.010 70 -0.029	—	
	• Clearance between tappet and shaft **C_{TS}**		0.02～0.05	0.10	
	• Clearance between tappet shaft and tappet bush **C_{TB}**		0.05～0.14	0.20	
	• Tappet bush inner diameter **D_{RP}**	ϕ 25	+0.10 25 +0.08	—	
	• Roller inner diameter **d_{RP}**	ϕ 25	+0.026 25 +0.018	—	
	• Clearance between bush and roller. **C_{RP}**		0.05～0.08	0.16	
	• Roller inner diameter **D_{RB}**	ϕ 36	+0.07 36 +0.05	—	
	• Bush diameter **d_{RB}**	ϕ 36	-0.02 36 -0.05	—	
	• Clearance between bush and roller **C_{RB}**		0.07～0.12	0.24	
	• Clearance between roller and tappet **C_{RT}**		0.5～0.7	—	

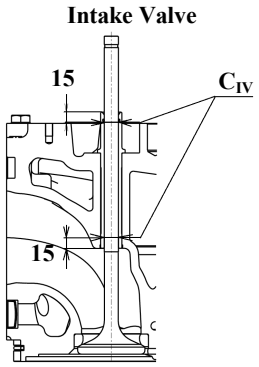


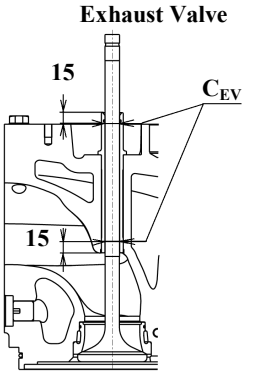


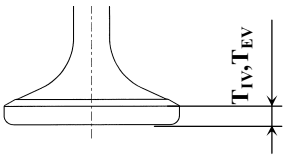


No.	Adjusting point	Nominal size (mm)	Clearance, Wear Limit		Description
			Standard (mm)	Permissible Limit (mm)	
21	Intake and Exhaust valve				
	• Intake valve stem diameter d_{IV}	ϕ 20	$20^{-0.06}_{-0.08}$	19.80	
	• Intake valve guide inner diameter D_{IV}	ϕ 20	$20^{+0.04}_{+0.02}$	20.25	
	• Clearance between intake valve stem and guide C_{IV}		0.08～0.12	0.45	
	• Exhaust valve stem diameter d_{EV}	ϕ 20	$20^{-0.08}_{-0.10}$	19.80	
	• Exhaust valve guide inner diameter D_{EV}	ϕ 20	$20^{+0.04}_{+0.02}$	20.25	
	• Clearance between exhaust valve stem and guide C_{EV}		0.10～0.14	0.45	
	• Intake valve com thickness T_{IV}		10.3	8.8	
	• Exhaust valve com thickness T_{EV}		10.3	8.8	
	• Bend of stem at center of stem				
	Center of guide section B_1		≤0.03	0.09	
	At center seating surface B_2		≤0.03	0.05	

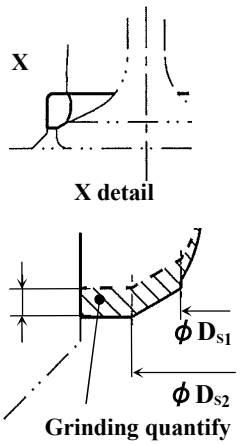


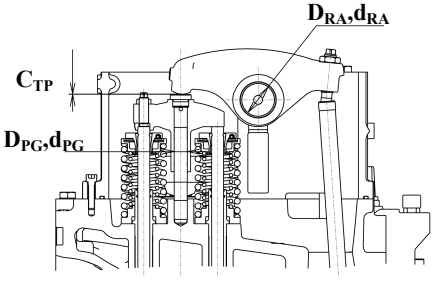




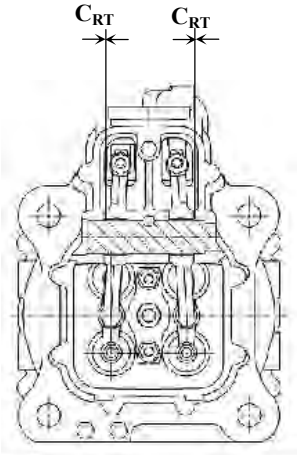


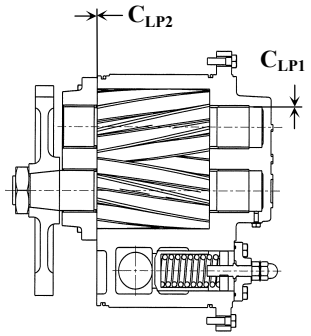
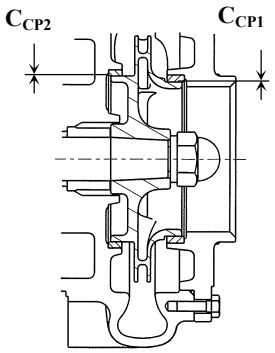
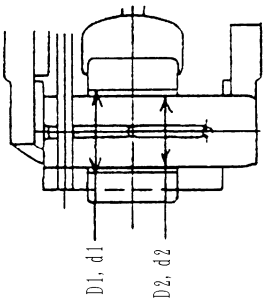
No.	Adjusting point	Nominal size (mm)	Clearance, Wear Limit		Description
			Standard (mm)	Permissible Limit (mm)	
22	Intake and Exhaust valve seat				
	• Grinding allowance : S				
	Intake valve seat			1.0	
	Exhaust valve seat			1.5	
	• Valve seat diameter				
	Inside : ϕ Ds1 (Intake valve)	ϕ 84	+0.1 84 0		
	(Exhaust valve)	ϕ 84	+0.1 84 0		
	Outside: ϕ Ds2 (Intake valve)	ϕ 94.3	94.3±0.1		
	(Exhaust valve)	ϕ 94.3	+0.3 94.3 -0.2		
23	Rocker arm				
	• Intake and Exhaust valve tappet clearance C_{TP}		0.5	—	
	• Rocker arm bush inner diameter D_{RA}	ϕ 55	+0.109 55 +0.04	—	
	• Rocker arm shaft diameter d_{RA}	ϕ 55	-0.010 55 -0.029	—	
	• Clearance between rocker arm bush and shaft D_{RA}- d_{RA}		0.05~0.138	0.2	
	• Pusher inside shaft D_{PG}	ϕ 22	+0.021 22 0	—	
	• Pusher guide diameter d_{PG}	ϕ 22	-0.02 22 -0.033	—	
	• Clearance between pusher and pusher guide D_{PG}- d_{PG}		0.02~0.054	0.1	
	Rocker arm bush				
	• Thrust clearance C_{RT}		0.2~0.6	—	





Clearance



No.	Adjusting point	Nominal size (mm)	Clearance, Wear Limit		Description
			Standard (mm)	Permissible Limit (mm)	
24	Lubricating oil pump • Clearance between bush and shaft C_{LP1} • Clearance between case and gear C_{LP2}		0.16~0.20 0.22~0.29	0.26 0.40	
	Note ・Correct case depth and adjust				
25	Cooling water pump • Clearance between impeller and suction cover C_{CP1} C_{CP2}	 ϕ 130 ϕ 130	 0.18~0.23 0.18~0.23	 1.5 1.5	
26	Fuel injection pump • Roller inner diameter D_1 • Bush diameter d_1 • Clearance between roller and bush D_1-d_1 • Bush inner diameter D_2 • Roller pin diameter d_2 • Clearance between bush and roller. D_2-d_2	 ϕ 48 ϕ 48 ϕ 38 ϕ 38			

5.2 Tightening Specification of Main Parts.

No.	Tightening Parts	Screw Size	Torque (Nm)	Tightening Angle (degree)	Jack oil Pressure (MPa) ※4	Remarks
1	**Cylinder block**					
	Main bearing stud bolt and nut	M42×3.0	—	—	180	—
	Main bearing side bolt	M27×2.0	700 ※**1**	—	—	(M)
	Cylinder head stud bolt and nut	M36×2.0	—	—	130	—
	Location bearing stud bolt and nut	M42×3.0	—	—	180	—
	Piston cooling jet nozzle hollow bolt	G1/2	200			(L)
2	**Crankshaft**					
	Balance weight stud bolt and nut	M36×2.0	—	—	130	—
	Crank gear bolt (Driving end side)	M22×1.5	480	—	—	(M)
	Crank gear stud bolt and nut (Free end side, without Damper)	M42×3.0	—	—	150	—
	Geislinger damper stud bolt and nut (Free end side, with dumper)	M42×3.0	—	—	150	—
	Free end side coupling shaft stud bolt and nut (With power take off shaft)	M42×3.0	—	—	150	—
3	**Flywheel**					
	Flywheel bolt	M48×3.0	Primary tightening 300	After primary tightening 25°	—	(M)
	Geislinger coupling-**BE63** type**< 6cyl >**					
	Flywheel／Geislinger coupling bolt (With flywheel and Geislinger coupling)	M48×3.0	Primary tightening 300	After primary tightening 40°	—	(M)
	Coupling bolt	M36×4.0	1470	—	—	(M)
	Geislinger coupling-**BC63** type**< 6cyl >**					
	Flywheel／Geislinger coupling bolt	M27×3.0	600	—	—	(M)
	Coupling bolt	M36×4.0	1600	—	—	(M)
	CENTA coupling - **CX-80** type**< 6cyl >**					
	CENTA coupling bolt	M18×2.5	240	—	—	(M)
	Coupling bolt	M30×3.5	1000	—	—	(M)
	Geislinger coupling-**BE72** type**< 8cyl >**					
	Flywheel／Geislinger coupling bolt	M48×3.0	Primary tightening 300	After primary tightening 15°	—	(M)
	Coupling bolt	—	—	—	—	(M)
	Geislinger coupling-**BC72** type**< 9cyl >**					
	Flywheel／Geislinger coupling bolt	M30×3.5	700	—	—	(M)
	Coupling bolt	—	—	—	—	(M)
	CENTA coupling-**CX-183** type**< 9cyl>**					
	CENTA coupling bolt	M20×2.5	240	—	—	(M)
	Coupling bolt	M30×3.5	1000	—	—	(M)

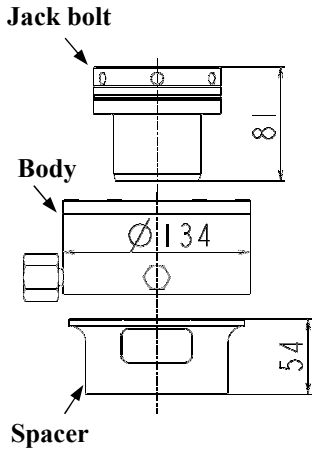
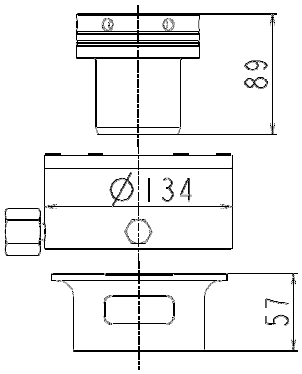
※1 : Main bearing lateral bolt is Tightening Procedure, Refer to CHAPTER 7.5.11.

No.	Tightening Parts	Screw Size	Torque (Nm)	Tightening Angle (degree)	Jack oil Pressure (MPa) ※4	Remarks
4	**Connecting rod**					
	Crank pin bolt	M25×2.0	Primary tightening 49	After primary tightening 85°	—	(M)
	Crank pin stud bolt and nut	M36×2.0	—	—	130	—
5	**Cam shaft**					
	Cam shaft bolt	M16×1.5	275	—	—	(L)
	Cam gear bolt	M16×1.5	275	—	—	(L)
	Thrust bearing bolt	M16×2.0	100	—	—	(L)
6	**Idle gear**					
	Idle gear stud bolt and nut (Driving end side)	M42×3.0	—	—	180	—
	Idle gear stud bolt and nut (Free end side)	M36×2.0	—	—	130	—
7	**Cylinder head**					
	FV sleeve nut	M70×2.0	588	—	—	(L)
	Rocker arm shaft support bolt	M16×2.0	150	—	—	(M)
8	**Fuel Injector**					
	Fuel injector nozzle nut	M39×1.5	300	—	—	(M)
	Fuel injector stud nut	M16×2.0	100 ※**2**	—	—	(O)
9	**Fuel injection pump**（**NICO** type）					
	Flange bolt	M14×2.0	90	—	—	(M)
	FIP delivery valve bolt	M12×1.75	75 ※**3**	—	—	(M)
	FO doorway hollow bolt	M32×1.5	130	—	—	(K)
	FIP stud bolt and nut	M18×2.5	235	—	—	(K)
10	**Fuel oil injection pipe**					
	Injection fitting bolt	M16×2.0	60 ※**2**	—	—	(M)
	FO high pressure pipe nut (FIP side)	M30×1.5	75	—	—	(M)
11	**FOFP**					
	Drive gear nut	M24×3.0	440	—	—	(L)
12	**Cooling water pump**					
	Driving gear nut	M30×3.5	343	—	—	(L)
	Impeller nut	M24×2.0	216	—	—	(L)

※2：Fuel injector stud nut and Injection fitting Bolt is Tightening procedure, Refer to CHAPTER 7.5.6.
※3：FIP delivery valve bolt is Tightening procedure, Refer to CHAPTER 7.5.5.
※4：Loosening amount of stud nut for hydraulic jack, Refer to attached list.

No.	Tightening Parts	Screw Size	Torque (Nm)	Tightening Angle (degree)	Jack oil Pressure (MPa)	Remarks
13	**Lubricating oil pump**					
	Driving gear nut	M45×2.0	785	—	—	(L)
14	**Turbocharger system**					
	Turbocharger bolt (A140, A145)	M24×3.0	960	—	—	(O)
15	**Tappet shaft**					
	Tappet shaft bolt	M16×2.0	235	—	—	(L)
16	**Cooling water pump driving gear**					
	Idle gear shaft bolt	M16×2.0	177	—	—	(L)
17	**Cooling water piping**					
	Flex coupling	—	15	—	—	—
18	**Bypass filter**					
	Hand clamp (FM200)	—	5~7	—	—	—
	Hand clamp (FM400)	—	7	—	—	—
	Hand clamp (FM600)	—	7	—	—	—
19	**Damper case cover**					
	Bearing case cover bolt For assembly	M20×1.5	280	—	—	(M)
	Bearing case cover bolt For mounting	M16×2.0	180	—	—	(L)
	Damper case cover bolt For mounting (With power take off shaft)	M16×2.0	180	—	—	(L)

Hydraulic jack combination

M42×3	M36×2
	

＊Loosening amount of stud nut for hydraulic jack (For details, Refer to CHAPTER 7.5)

Tightening Parts	Screw Size	Jack Oil Pressure(MPa)	Rotating Angle	Loosening amount of nut(mm)
Main bearing stud nut	M42×3	180	1 rotation	3
Locating bearing stud nut	M42×3	180	1 rotation	3
Cylinder head stud nut	M36×2	130	2 rotation and a half	5
Balance weight stud nut	M36×2	130	1 rotation	2
Crank gear stud nut	M42×3	150	1 rotation	3
Geislinger damper stud nut	M42×3	150	1 rotation	3
Free end coupling shaft stud nut	M42×3	150	1 rotation	3
Crank pin stud nut	M36×2	130	1 rotation	2
Idle gear stud nut (Driving end side)	M42×3	180	1 rotation	3
Idle gear stud nut (Free end side)	M36×2	130	1 rotation	2

Tightening torque specification.

(Strength classification 4.8 Material : equivalent JIS SS400)

Screw size	Tightening torque (Nm)			Remarks
	Standard	Minimum	Maximum	
M8	9.8	8.8	14.7	(K)
M10	24.5	19.6	29.4	(K)
M12	44.1	34.3	49.0	(K)
M16	98.0	88.2	118	(K)
M20	216	186	245	(K)
M22	274	216	304	(K)
M24	363	284	392	(K)
M30	706	637	784	(K)
M36	1176	980	1372	(K)

Tightening torque specification.

(Strength classification 8.8 , 10.9 Material : equivalent SCM435)

Screw size	Tightening torque (Nm)			Remarks
	Standard	Minimum	Maximum	
M8	22.0	17.6	26.4	(K)
M10	44.0	35.2	52.8	(K)
M12	76.0	60.8	91.2	(K)
M16	190	152	228	(K)
M20	370	296	444	(K)
M22	500	400	600	(K)
M24	650	520	780	(K)
M30	1260	1000	1500	(K)
M36	2250	1800	2700	(K)

Note

1.Clean bolts, nuts and screws, and to check that they are free of damage, them by hand until they come into with their seats.

2.Meanings of the symbols in the "Remarks column"

(M) : Apply MOLYBDENUM DISULFIED to the screw threads and seats surface.

(L) : Apply LOCKTITE 243 or equivalent to the screw threads.

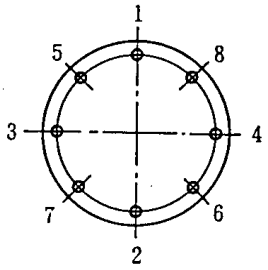
(O) : Apply lubricating oil to the screw threads.

(K) : Tighten after cleaning in light oil.

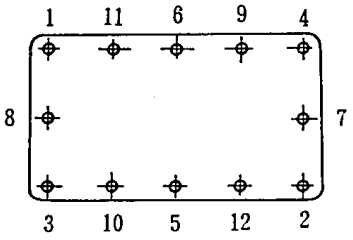
3. Tighten bolt and nut in the following three step to assure even tightening.

Primary tightening → **Intermediate tightening** → **Final tightening**

Tighten diametrically opposite bolts (or nuts) by turns as shown below.



Tightening order
1,2,3,4 …… 8

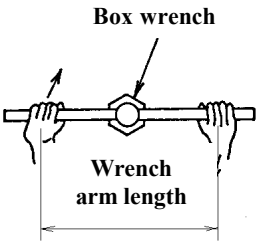


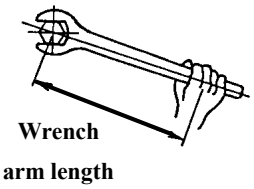
Tightening order
1,2,3,4 …… 12

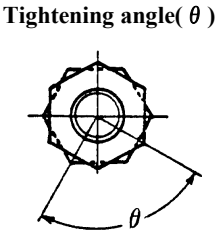
4.Tightening force is specified as follows

Primary tighten : To turn a bolt or nut to bring it into close contact with its seat

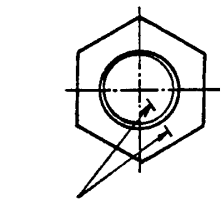
The force exerted by one person is assumed to be about 490N.(Single hand about 294N)
When using a box wrench, the standard tightening force is based on a position close to the center of the wrench held with both hands.

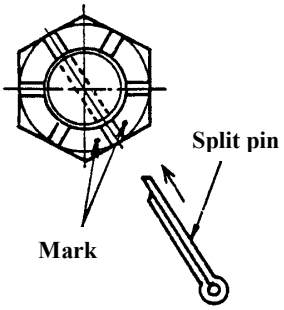






5.The counter-mark on bolts and nut were punched at the time of engine manufacture.
When reassembling the engine, use them only as rough yardsticks and be sure to correctly tighten them with the specified torque.





If a nut has split pin, change its position where necessary.

5.3 Temperature settings (STANDARD)

No.	Item		Temperature °C			
			Standard	Thermostat	Alarm	Trip
1	Lubricating oil	System lubricating oil (Engine inlet)	70~80	71~79.5	85≤	90≤
2	Cooling water (Jacket water)	Engine inlet	—	—	—	—
		Engine outlet	70~80	82-90	less than 50%load 88≤ over 50% load 85≤	90≤
3	Fuel oil	Diesel fuel oil	—	—	—	—
		Heavy fuel oil	Heat up to be 12±1.5cSt (mm^2/s) {60±5s/RWNo.1}			

5.4 Pressure settings(STANDARD)

No.	Item			Pressure [MPa]					
				Variable Engine Speed			Constant Engine Speed		
				Standard	Alarm	Trip	Standard	Alarm	Trip
1	Lubricating oil	※ System lubricating oil (Engine inlet)		0.3~0.6	≤0.2	≤0.15	0.5~0.6	≤0.45	≤0.4
		Turbocharger lub oil (T/C inlet)		0.2~0.45	≤0.13	≤0.06	0.3~0.45	≤0.13	≤0.06
2	Cooling water	Jacket Water	Engine inlet	0.1~0.35	≤0.05	—	0.2~0.35	≤0.1	—
		Low temp Water	AC inlet	0.1~0.25	≤0.05	—	0.1~0.25	≤0.05	—
3	Fuel oil	Diesel fuel oil		0.05~0.15	≤0.03	—	0.05~0.15	≤0.03	—
		Heavy fuel oil (≤380cSt at 50℃)		0.3~0.6	≤0.25	—	0.3~0.6	≤0.25	—
4	Stating and control air	Starting air		2.2~3.0	≤1.8	—	2.2~3.0	≤1.8	—
		Control air		0.8~1.0	≤0.6	—	0.8~1.0	≤0.6	—

Note :(1) Aklarm and trip devices are equipped depend on the specification
(2) These standard values should be kept on normal operating conditions.
(3) These table show standard values.
The setting values are determined with specification

※ In case of idling speed, it is possible that lubricating oil pressure is lower than standard value by oil temperature.

※ When the variable engine speed spec engine operate at rated speed, lubricating oil pressure set the standard pressure as constant engine speed spec.

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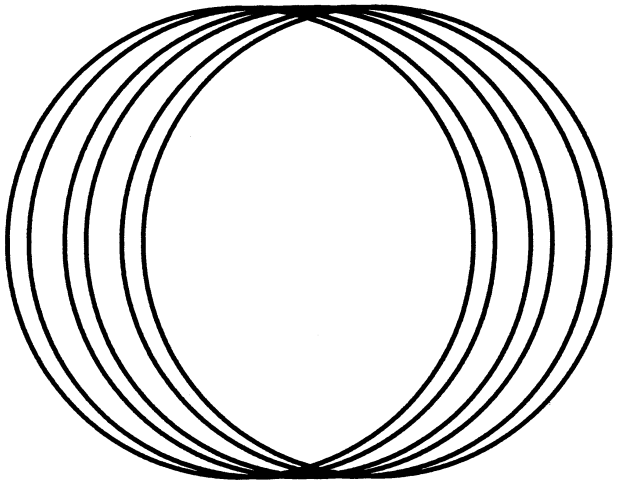

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